ELECTROMAGNETIC SCATTERING FROM ANISOTROPIC INHOMOGENEOUS IMPEDANCE CYLINDER OF ARBITRARY SHAPE ABOVE PEC SURFACE

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ELECTROMAGNETIC SCATTERING FROM ANISOTROPIC INHOMOGENEOUS IMPEDANCE CYLINDER OF ARBITRARY SHAPE ABOVE PEC SURFACE

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MOHAMED MILAD SALIM AINDALA

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April 2019

I certify that in my opinion the thesis submitted by MOHAMED MILAD SALIM AINDALA titled "ELECTROMAGNETIC SCATTERING FROM ANISOTROPIC INHOMOGENEOUS IMPEDANCE CYLINDER OF ARBITRARY SHAPE ABOVE PEC SURFACE" is fully adequate in scope and in quality as a thesis for the degree of Master of Science.

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This thesis is accepted by the examining committee with a unanimous vote in the Department of Electrical and Electronic Engineering as a Master Thesis.Aug29, 2019

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...../...../2019

The degree of Master of Science by the thesis submitted is approved by the Administrative Board of the Graduate School of Natural and Applied Sciences, Karabük University.

Prof. Dr. Filiz ERSÖZ ....
Deputy of Graduate School of Natural and Applied Sciences

MOHAMED MILAD SALIM AINDALA

“I proclaim that all the data inside this theory has been accumulated and exhibited as per scholarly controls and moral standards and I have as indicated by the prerequisites of these directions and standards referred to every one of those which don't begin in this work also.

MOHAMED MILAD SALIM AINDALA

ABSTRACT

M. Sc. Thesis

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In this study, the electromagnetic scattering from anisotropic inhomogeneous impedance cylinder of arbitrary shape located above perfect electric conducting (PEC) surface is investigated for both TM and TE plane wave illuminations. In the solution of scattering problem, scattered TE and TM fields are represented as single layer potentials. Using the boundary condition and jump relations of single layer potential on the boundary, boundary integral equation is obtained and solved via computation effective Nyström method which has exponential convergence property. The results obtained by this method are compared with those obtained by analytical method whose solution available for electromagnetic scattering of inhomogeneous anisotropic impedance circular cylinder in free space and good agreements between this method and analytical method are observed.

Key Words : Electromagnetic Scattering, Impedance Boundary Conditions, PEC surface, Anisotropic Boundary Conditions.

Science Code : 905.1.034

ÖZET

Yüksek Lisans Tezi

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Bu çalışmada TE veya TM düzlemsel bir dalga ile aydınlatılmış mükemmel bir düzlem üzerinde bulunan homojen olmayan keyfi kesitli anizotropik bir empedans silindirinden elektromagnetik dalgaların saçılması incelenmiştir. Saçılma probleminin çözümünde saçılan TM ve TE dalgaları tek tabakalı bir potansiyel olarak ifade edilmiştir. Sınır koşulu ve tek tabakalı potansiyellerin sıçrama bağıntıları kullanılarak yüzey üzerinde bir integral denklem elde edilmiş ve bu denklem üstel yakınsama özelliğine sahip Nyström yöntemiyle çözülmüştür. Elde edilen sonuçlar analitik çözümü mevcut olan boş uzayda elektromagnetik dalgaların homojen olmayan dairesel anistropik empedans silindirinden saçılmasına ilişkin sonuçlarla karşılaştırılmış ve sonuçlar arasında iyi bir uyum gözenmiştir.

Anahtar Kelimeler : Elektromanyetik Saçılma, Empedans Sınır Koşulları, PEC yüzeyi, Anizotropik Sınır Koşulları.

Bilim Kodu : 905.1.034

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NOMENCLATURE

Acronyms / Abbreviations

IBC : Impedance Boundary Condition
PEMC : Perfect Electric and Magnetic Conductor
PAB : Perfectly Anisotropic Boundary
PEC : Perfect Electric Conductor
PMC : Perfect Magnetic Conductor
SHS : Soft-and-Hard Surface
GSHS : Generalized Soft-and-Hard Surface
PO : Physical Optics
PA : Perfectly Anisotropic

Symbols

a : vector
$\hat{a}$ (= a/|a|) : unit vector
ab : dyad
A : dyadic (a polynomial of dyads)
E : electric field
H : magnetic field
D : electric flux density
B : magnetic flux density
J : electric current density
M : magnetic current density
ρ : electric charge density
ρm : magnetic charge density
ǫ : electric permittivity
µ : magnetic permeability

ω	: angular frequency
k	: wave number
L	: linear (integral) operator
O(f(n))	: proportional to the function f(n)

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

PART 1

INTRODUCTION

In electrical engineering the complications involve in modelling electromagnetic scattering in different particles is a usually experienced as a very important point of concern. In this regard the scattering of particles includes different scatters which are being exposed to electromagnetic fields, at that point the fields must be settled in numerous districts inside and outside of the scatters. The more unique and different, the electrical properties of the scatters are, the more troublesome and the more fathoming the scattering process becomes.

If the surface structure of the scatters is sufficiently complicated, it is very difficult to find the desired solution even for the scattering problem containing a single particle. It might be more complex for the scattering problems containing numerous particles. Moreover, if the surface structure of the scatters is complex the complexity of scattering problem also increases. Here are some of the most commonly encountered scattering problems surfaces

1. Corrugated surfaces of various cross-sectional shapes,
2. Composite material mixtures,
3. Planar antenna structures,
4. Fractal surfaces,
5. Many meta-material realizations

The above-mentioned surfaces can also be seen in (Fig.1)

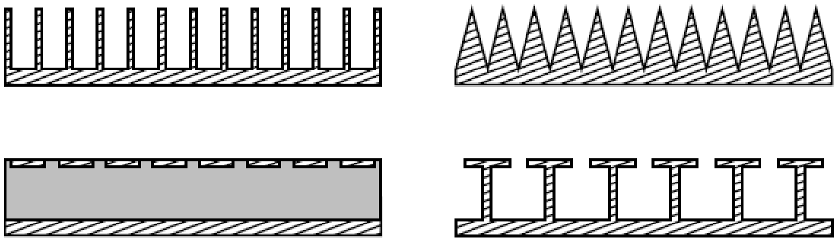

Figure 1.1. Different realizations of complex surfaces.

If the area of interest are the fields just outside the scatters, the scattering problems are easy to be simplified even with the numerous amounts of particles and the original complicated surface structure can be neglected to solve the scattering issues. The scattering problem can be solved easily by using boundary conditions and it will contain a smother and simpler surface, so that the most efficient numerical solution can be provided. An extraordinary number of scattering issues can be incredibly found if, rather our area of concern is surface structure or number of particles in the surface structure is very large.

Regardless of any case, the boundary conditions are a numerical romanticizing of a complex circumstance and finding a reasonable one for the given issue isn't a trifling errand. Numerous components must be considered on the off chance that one wishes to make such an estimate: the shape of the first scatters, the infiltration profundity, the nature and the bearing of the episode field, and so on. Luckily, for some sorts of surfaces there exists an impedance boundary condition that is an adequately precise romanticizing. Be that as it may, finding a well-fitting limit condition is normally just the initial step on the way to take care of the considered issue. As the taking care of a confounded dispersing issue typically includes some kind of numerical arrangement strategy, this presents another arrangement of problems. Executing a precise numerical technique for tackling a dispersing issue with an explicit limit condition is regularly not a direct process. Surface necessary condition strategies are regularly utilized in tackling electromagnetic dissipating issues yet finding a productive and precise formulation for a given issue might be troublesome. Likewise, numerical mix techniques, in spite of having been cautiously considered since the introduction of logical processing stays still a dangerous region.

There are likewise circumstances when the examination of the dispersing from a surface characterized by a limit condition isn't of essential intrigue. The objective might be to discover or to blend a material or a meta-material that relates to an explicit sort of a limit condition. These circumstances may emerge, for instance, when attempting to understand certain explicit dissipating attributes for a receiving wire, and a reasonable limit condition would fulfil these necessities.

In this postulation the focal point of the exploration has been the investigation of the electromagnetic dispersing from anisotropic impedance surfaces, i.e. surfaces that have some favoured bearing for the electric and attractive fields. The objective was to grow new expository and numerical strategies for dissipating investigation. The exploration was stretched into two issue regions.

The primary territory was the hypothetical investigation of the dissipating properties of complex anisotropic limit conditions, and furthermore the investigation of their conceivable acknowledge. The second issue territory was the numerical butt-centricities of dissipating from surfaces that can be approximated by anisotropic limit conditions. Notwithstanding contemplating the numerical strategies, the second piece of the examination additionally prompted the improvement of some new outcomes for the numerical incorporation systems included.

Notwithstanding, it isn't adequate to propose a numerical arrangement technique for an issue without checking its exactness. Additionally, when discovering conceivable genuine ionizations for complex limit conditions it must be cautiously confirmed that the combined material precisely delivers the ideal limit condition also, the dissipating conduct. This implies by and large that the full, accurate model of the first unpredictable surface structure must be examined. This may turn out to be dangerous as the surface may have some electrically little subtleties, with the goal that the precise displaying would require impracticable computational assets.

Boundary conditions corresponding to the electric and magnetic fields on the surface of the object play an important role in troubleshooting. A condition which gives some sort of association of the magnetic and the tangential electric fields on a given surface and allows us to study any mutual relation between these two factors is called as the impedance boundary condition (IBC). The relationship among the magnetic and electric fields is elaborated by means of a constant called as the surface impedance. The concept of IBC is given by two scientists named as Leontovich [1] and the other person was Shchukin [2]. According to them, the most basic type of the IBC which is generally used to enhance the coverings and also the dielectrics which show more dissipation effects was the SIBC which is easily observable in our environment[6].In general, it is believed that the co efficient that generally is indicated on the surface material is independent of the surroundings but, It is estimated that it depends on the position of the IBC and is associated with a constant coefficient [3-4]. On the other hand, surface impedance can be a position function when examining more accurate SIBCs and anisotropic ones for simulating anisotropic surfaces and corrugated surfaces. For example, soil, sand, forest and so on. When an uneven surface of different parts, modeled with an IBC, becomes a function of the impedance position on the surface. Therefore, a more general IBC should be used to study the complex waste of materials. SIBC have been proposed in [4-6] and Nystrom method has been investigated in [7] to explain the phenomena of scattering from inhomogeneous isotropic impedance cylinder of arbitrary with nonzero surface impedance. Scattering from anisotropic inhomogeneous impedance circular cylinder has been presented by series of expansion method [9]. Scattering from anisotropic inhomogeneous impedance cylinder of arbitrary shape is solved by physical optics (PO) method in [10].

The major objective of this discussion and analysis is to indicate a proper outcome or technique by the use of which these scattering problems on the imaginary surfaces and imaginary boundaries, regardless of their shapes and sizes, can be averted. And these solutions have to be found against the TE and TM optical illumination planes against the anisotropic medium. The method discussed in this study is based on how the TE and TM plane waves are scattered in any single layered medium. Not only this, but a relation is also developed which can depict the scattering in the single layered potential mediums.

The analysis has been divided into 4 parts which effectively discuss the problems, its solutions, the verifications and certain common examples as well. The part 2 contains the solution to the scattering issue in detail. In the part 3, the different examples have been quoted and their results and conclusions have been elaborated and cross matched under the anisotropic medium and by using the analytical techniques as well [8]. All the results match each other showing the scrutiny and the authenticity of the study conducted. The last part or the part 4 contains the results, any possible suggestions or improvement quotes in this regard.

1.1. MOTIVATION AND BACKGROUND

The theory of electromagnetic wave propagation has been the focus of research and has been extensively studied in this field for a long time. But there is a serious analysis until recently. The development of computer technology has increased the possibility of modeling and increased interest in electromagnetic wave propagation. The difficulty of numerical methods suggests that a large amount of information is required in the description of high frequency electromagnetic fields.

The scattering problems for excellent electrical conductors are covered with electrical conductors and complex layers. The complex layer is considered to be one surface, along with the surface of the crude surface or the speed selector. In the present conditions, the selector surface or commonly called the frequency selector surface is generally applied to the coverings manually for a better experience.

There are two approaches that can be used to solve the Maxwell's equation in harmonic regime. One of the solutions is the volume approach and the other one is the integral approach. The volume approach generally works on the basis recognizing the outer and inner volume of any given object and by considering a superficial fictitious boundary. This approach generally works on the physical aspects of consideration and in order to provide results, it requires a large number of unknown figures. On the other hand is the integral approach. It is generally applicable to homogenous bodies. In this approach the aspects that are not known are generally placed at the edges of the surface object and the basic error or problem is generally confined to a set of equations that find the possible outcome. This method can be used both for the three dimensional and the two-dimensional approaches of studying objects.

Limit values should be applied to ensure a unique solution to the problem of limit values Condition. Usually we get a standard impedance operator called Leontovich. This approach does not depend upon the angle of incidence on objects; rather it depends upon the higher order equations for object and surface studies and impedance measures

1.2. METHODOLOGY AND RESEARCH APPROACH

The approach and methodology used in this master's thesis can be seen as a flow diagram, visualized in Fig. [1.2] and will be further described in this section. This thesis project first consisted of a phase where expertise about the electromagnetic scattering problems and their solution, for PEC surface of arbitrary shaped cylinder, was built up. In order to do this, several scientific papers were studied. To be able to investigate the aims of this master's thesis, a scattering problem was needed. The model was developed from scratch and necessary functions were implemented in MATLAB, partly using built-in MATLAB functions. This resulted in a simulation environment used to perform the investigations needed to reach the goals of this thesis. During this process a good understanding of the simulation framework, system model and communications theory behind it was built up.

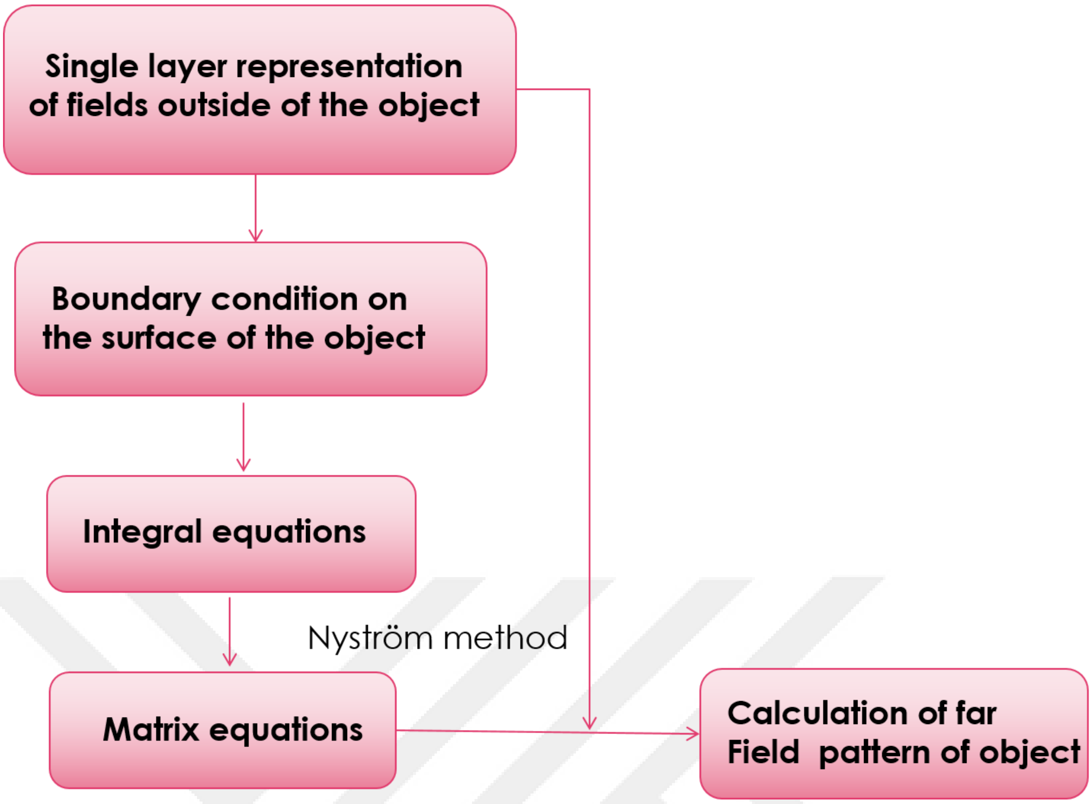

Figure 1.2. Scheme of methodology.

1.3. THESIS CONTRIBUTION

In this work, the Mie Scattering method has been applied to analyze the EM scattering characteristics of arbitrarily shaped PEC targets coated with the electric anisotropic media. The application of the Mie Scattering method significantly reduces the complexity of the computation of the impedance matrix as well as the solution time. It can be concluded that this method is still very simple and efficient in the construction of the impedance matrix elements although the scattering target is very complex with hybrid PEC and anisotropic in it.

Furthermore, this method can be easily extended to the analysis of the scattering problem of PEC targets coated with multi-layered electric anisotropic media. Though this method is simple and efficient in the computation of the impedance matrix, the Mie Scattering method itself cannot reduce the memory requirement similarly as the traditional MoM because the impedance matrix does not change its original “full” characteristic. In the author’s opinion, it is better to combine this method with other fast algorithms, such as the characteristic basis function method, to analyze the electrically large objects.

1.4. THESIS STRUCTURE

The thesis structure is organized as follows.

Chapter 2 provides the basics of the Impedance Boundary Conditions including its background material along with the linear and non-linear computation schemes for anisotropic media. Moreover, the different types of boundary conditions has been discussed briefly to develop the Electromagnetic Scattering problem formulation.

Chapter 3 provides the brief information on Electromagnetic Scattering and the PEC surface has been analyzed following the scattering problem of anisotropic medium.

Chapter 4 provides a problem formulation and different optimizing techniques have been followed to simply the problem.
Chapter 5 provides the numerical analysis of the proposed system to implement the Mie Scattering to solve the problem and the results have been shown in form of graphs and discussions.

Chapter 6 provides the final conclusion and drawbacks in the research work done. Moreover, the future scope of the study has been discussed.

PART 2

ANISOTROPIC INHOMOGENEOUS IMPEDANCE

2.1. THE IMPEDANCE BOUNDARY CONDITION

The impedance boundary condition (IBC) is defined as the relationship between the fields on surface which are the time-harmonic electrical and magnetic fields respectively [8]. These conditions are explained in detail in [1,2,8,11] and can be seen in Fig.3. Considering a traditional reflective boundary condition and a fully non-reflective boundary condition, there exists an IBC and a partial reflection going from full-reflection to no-reflection. After scattering if the area of interest is outside of the surface, the IBC can be of great importance to model the scattering problems.

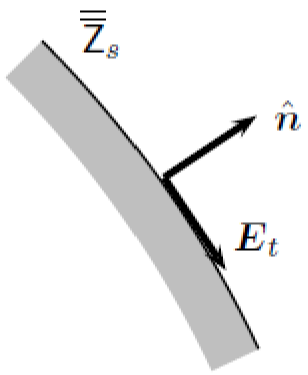

Figure 2.1. Impedance boundary conditions.

To understand the concept of field it is very important to first understand the Maxwell equations.

Let's look into the Maxwell equation in frequency domain (with time factor ($e^{-j\omega t}$))

$$E\,(r, t) = E(r)e^{j\omega t}, \quad H(r, t)= H(r)e^{j\omega t}$$

$$\nabla \times E = j\omega B, \tag{2.1}$$

$$\nabla \times H = J + j\omega D, \tag{2.2}$$

$$\nabla \cdot B = 0, \tag{2.3}$$

$$\nabla \cdot D = \rho. \tag{2.4}$$

Sometimes we introduce current density M to equation 1 for symmetry and can be seen as below equation

$$\nabla \times E = j\omega B - M, \tag{2.5}$$

and similarly, introducing the magnetic charge density ρm to equation (3), we will get

$$\nabla \cdot B = \rho m. \tag{2.6}$$

As we notice two vector and two scalar equations and four vector unknowns in Maxwell equations (1)-(4). We need to write the equation in general form to find a unique solution for the fields and it would be as medium equations (1)

$$D = \varrho \cdot E + \xi \cdot H, \tag{2.7}$$

$$B = \zeta \cdot E + \mu \cdot H. \tag{2.8}$$

For a linear environment, binary media parameters depend on and, ξ, ζ, μ by electric and magnetic fields. Media settings mask all physical events in the media. Macroscopic electromagnetic fields behave the same way for the same two different environments although the media are essentially different physical; average parameters. If the surface components are discontinuous, then the different form of Maxwell equations is invalid in any place because the discontinuous surfaces generally have some infinite values for the coefficients. Parameters are not stable because some component components can be permanent Therefore, their derivatives will be limited. Unfortunately, people often face such a situation. For instance, any object may be composed of different kinds of material and will have different parameters then which would be a problem in providing scrutiny in results.

In this case, the situation is occasionally associated with the source of an uninterrupted field and source and these conditions can be written as:

$$\widehat{n_1} \times E_1 + \widehat{n_2} \times E_2 = -M \tag{2.9}$$

$$\widehat{n_1} \times H_1 + \widehat{n_2} \times H_2 = J \tag{2.10}$$

where E_1 and H_1 represents the electric field and the magnetic field in the volume with medium coefficients ϱ1, μ1, the unit normal vector $\widehat{n_1}$ on the interface pointing to the volumeV_1, and similarly for the subscript is for the volume V_2(see Fig. 4). J and M is the electric and magnetic, current sources at the interface. If the surface area of the interface completely restricts the surface S, the problem of original dispersion can be significantly simplified. The equivalent principle of Huygens defines the same surface speed on the S surface, which also represents a field produced by the original source in V_2. (see Fig. 5).

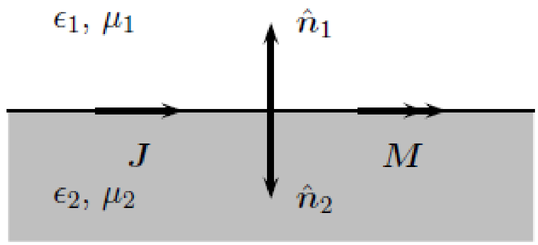

Figure 2.2. Two media interface.

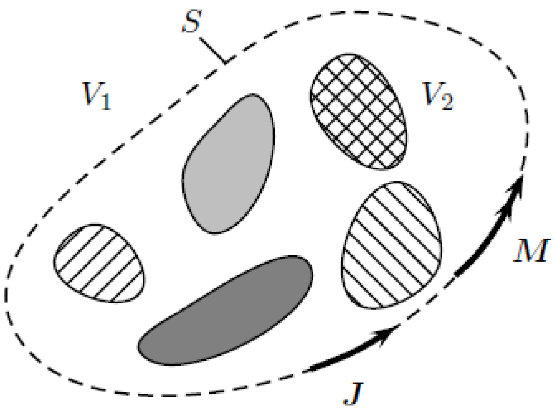

Figure 2.3. Huygens ’equivalence principle and equivalent surface currents.

These equal surface current therefore produces the same field outside V2 as the original source. Deposits E2 and H2 can be obtained from the interface conditions (9), (10) by requiring V2 to pass through the outside. Following this and having a view at the figures, we may state

$$J = \hat{n} \times H \qquad (2.11)$$

$$M = -\hat{n} \times E \qquad (2.12)$$

For fields on the boundary, with ˆn pointing away from the region V2. For border regions, V2 is far from that area. The original surface can be covered by the S surface, and the surface problem and the equivalent source can be used to replace the original problem of dispersal with the new dispersal problem [11].

2.2. PERFECTLY ANISOTROPIC BOUNDARY

The concept of perfect anisotropic boundary (EBP) is determined by point’s binary impedance without isotropic components [12]. It is recommended that the PDB is implemented in the form of anisotropic metamaterial sheet. EBP can be used as a simple rotational polarization converter that converts the polarized parts of the wave into polarization and elliptical transfer, and vice versa. It was also shown that, unlike the conventional barrier limits, EBP can support two polar surface surfaces that extend to some directions along the boundary conditions.

IBC represents a linear connection between the electrical and magnetic field components of the contact surface. On a smooth surface z = 0, showing a normal surface point, this condition can be implemented as shown as follows.

$$E_t = -\overline{\overline{Z_s}}\,.\,(\boldsymbol{u}_z \times H), \quad -\boldsymbol{u}_z \times \ H = \ \overline{\overline{Y_s}}\ .\,E_t \tag{2.13}$$

where$-\overline{\overline{Z_s}}$ is the surface impedance and $\overline{\overline{Y_s}}$ the surface admittance dyadic and the subscript t denotes component transverse to $\boldsymbol{u}_z$. In the past IBCs have been used as convergence of physical boundaries when replaced with simple conditions or in areas with gaps or operator numbers. Recently, a method of presenting a binary drug in terms of an isotropic layer, where the complete analytical relationship between parameters was put forth. In this study a specific part of the impedance limit was determined, and some properties were studied. Facial impedance and the acceptability of the dyadic can be described as a two-dimensional diamond. Because they are in complete correspondence with the boundry conditions(1), where $-\overline{\overline{Z_s}}$ or $\overline{\overline{Y_s}}$ are either algebraic or operator quantities [12].

The surface-impedance and admittance dyadic can be characterized as two-dimensional dyadic, because they satisfy

$$\boldsymbol{u}_z.\overline{\overline{Z_s}} = \ \overline{\overline{Z_s}}.\boldsymbol{u}_z = 0, \qquad \boldsymbol{u}_z\,.\overline{\overline{Y_s}} = \quad \overline{\overline{Y_s}}\,.\boldsymbol{u}_z\,. \tag{2.14}$$

A two-dimensional binary number can be expanded by giving a single two-dimensional vector, providing a fourth basic binary number = ¼ that is unit vectors $\boldsymbol{u}_x$, $\boldsymbol{u}_y$ satisfying $\boldsymbol{u}_x$ = $\boldsymbol{u}_y$ ¼ $\boldsymbol{u}_z$. The fundamental dyadic can be evenly shown as follows [9]

$$\overline{\overline{I}} = \boldsymbol{u}_x\boldsymbol{u}_x + \boldsymbol{u}_y\boldsymbol{u}_y \tag{2.15}$$

$$\overline{\overline{J}} = \boldsymbol{u}_y\boldsymbol{u}_x - \boldsymbol{u}_x\boldsymbol{u}_y = \ \boldsymbol{u}_z \times \overline{\overline{I_t}} \tag{2.16}$$

$$\overline{\overline{K}} = \boldsymbol{u}_x\boldsymbol{u}_x - \boldsymbol{u}_y\boldsymbol{u}_y \tag{2.17}$$

$$\overline{\overline{L}} = \boldsymbol{u}_x\boldsymbol{u}_y - \boldsymbol{u}_y\boldsymbol{u}_x \tag{2.18}$$

2.3. ISOTROPIC BOUNDARY CONDITION

The four main groups can be split into two groups. The landscape does not depend on binary basic binary choice and anti-asymmetric binary vector. In fact, defining the transformation by

$$\begin{pmatrix} \boldsymbol{u}_x \\ \boldsymbol{u}_y \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} \boldsymbol{u}_x{}' \\ \boldsymbol{u}_y{}' \end{pmatrix} \tag{2.19}$$

We can easily show that

$$\boldsymbol{u}_x\boldsymbol{u}_x + \boldsymbol{u}_y\boldsymbol{u}_y = \boldsymbol{u}_x{}'\boldsymbol{u}_x{}' + \boldsymbol{u}_y{}'\boldsymbol{u}_y{}' \tag{2.20}$$

As linear combination of $\overline{\overline{I_t}}$ and $\overline{\overline{J}}$ do not depend on any particular vector in the X-Y plane, they recognize part of a two-dimensional isotropic duality, such as linear connection, and do not rely on any vector at X-Y level. Another method of determining isotropic binary classes is the state [9]

$$\overline{\overline{D}}{}^{\times}_{\times}\boldsymbol{u}_z\boldsymbol{u}_z = \overline{\overline{D}} \tag{2.21}$$

where the double cross product is defined by

$$(\boldsymbol{ab})^{\times}_{\times}(\boldsymbol{cd}) = (\boldsymbol{a} \times \boldsymbol{c})(\boldsymbol{b} \times \boldsymbol{d}) \tag{2.22}$$

Isotropic conversion of dyadic is isotropic. In addition, the point of the isotropic binary product as $\overline{\overline{J}}.\overline{\overline{J}} = -\overline{\overline{I_t}}$ is isotropic binary. If the acceptable impedance or duct can be represented by a two-dimensional isotropic binary, the impedance restriction may be called isotropic. The isotopic edge or boundary can be illustrated as follows

$$\overline{\overline{J}}.\overline{\overline{J}}\,\overline{\overline{Y_s}} = \overline{\overline{Y_I}}\,\overline{\overline{I_t}} + \overline{\overline{Y_J}}\,\overline{\overline{J}} \tag{2.23}$$

For the general scalar quantities Y$_I$ and Y, The isotropic surface admittance$\overline{\overline{Y}}_s.Y_I = \overline{\overline{I}}_t$ It can be obtained by a chunk of transversely isotropic medium $\overline{\overline{\epsilon}}_t = \epsilon_t \overline{\overline{I}}_t$, $\overline{\overline{\mu}}_t = \mu_t \overline{\overline{I}}_t$, while the component $\overline{\overline{Y}}_s = Y_J \overline{\overline{J}}$ requires gyro tropic material. The total isotropic boundary usually pegs the waves from a random aircraft. In fact, for a normal event, the inverse binary can easily be shown in the same isotropic form

$$\overline{\overline{R}} = R_I \overline{\overline{I}}_t + R_J.\overline{\overline{J}}. = \overline{\overline{R}}(\overline{\overline{I}}_t \cos\theta + \overline{\overline{J}} \sin\theta) \tag{2.24}$$

Any linearly polarized transverse vector **v** is scaled as

$$\overline{\overline{R}}.\mathbf{v} = \mathrm{R}(\mathbf{v}\cos\theta + \boldsymbol{u}_z \times \overline{\overline{J}}\sin\theta) \tag{2.25}$$

Therefore, the polarization of an aircraft wave varies with the main factor of the R variation and the polarization rotation, reflecting the isotropic boundary

2.4. PERFECT ANISOTROPIC BOUNDARY (PAB)

Unlike an isotropic binary group $\overline{\overline{I}}_t$ and $\overline{\overline{J}}$, it depends on the basic binary and the main select vector$\boldsymbol{u}_x$, $\boldsymbol{u}_y$.. If you have a 2D binary, binary and component, you can call it anisotropic. Now we will define the perfect anisotropic (PA) duality, the classical combination, and the class of dual aspect. Thus

$$\overline{\overline{D}} = D_K \overline{\overline{K}} + D_L \overline{\overline{L}} \tag{2.26}$$

is perfectly anisotropic. There is another way to define the space of two-dimensional PA dyadics which can be seen as following condition [9]

$$\overline{\overline{D}}{}^{\times}_{\times} u_z u_z = \overline{\overline{D}} \tag{2.27}$$

Making the transformation [7], we have

$$\overline{\overline{D}} = \overline{\overline{K}}(D_K \cos 2\theta - D_L \sin 2\theta) + \overline{\overline{L}}(D_L \cos 2\theta + D_K \sin 2\theta) \tag{2.28}$$

With

$$\overline{\overline{K}} = \boldsymbol{u}_x{}'\boldsymbol{u}_x{}' - \boldsymbol{u}_y{}'\boldsymbol{u}_y{}' \quad \overline{\overline{L}} = \boldsymbol{u}_x{}'\boldsymbol{u}_y{}' + \boldsymbol{u}_y{}'\boldsymbol{u}_x{}' \tag{2.29}$$

Now choosing θ so that

$$D_L \cos 2\theta + D_K \sin 2\theta = 0$$

The dydadic $\overline{\overline{D}}$ becomes a multiple of $\overline{\overline{K}}$ while choosing

$$D_K \cos 2\theta - D_L \sin 2\theta = 0$$

Accordingly, based on appropriately selected vectors, any AU can be represented as a binary or single group binary group. However, if the DL component is very complex, the central DK vector identified can be complex. We can display PA back easily.

$$\overline{\overline{D}}^{-1} = \frac{D_K\overline{\overline{K}} + D_L\overline{\overline{L}}}{D_K^2 + D_L^2} \tag{2.30}$$

but the dot-product of two PA dyadic is an isotropic dyadic because of the relations

$$\overline{\overline{K}}.\overline{\overline{K}} = \overline{\overline{L}}.\overline{\overline{L}} = \overline{\overline{I}}_t \qquad \overline{\overline{L}}.\overline{\overline{K}} = -\overline{\overline{K}}.\overline{\overline{L}} = \overline{\overline{J}}$$

In analogy to the definition of the isotropic boundary, let us call the boundary defined by the surface admittance of the form

$$\overline{\overline{Y}}_s = Y_K\overline{\overline{K}} + Y_L\overline{\overline{L}} \tag{2.31}$$

a perfectly anisotropic boundary (PAB). Another way to define the PA boundary is by requiring the condition [9].

$$\overline{\overline{Y}}_s {}^{\times}_{\times} \boldsymbol{u}_z \boldsymbol{u}_z = -\overline{\overline{Y}}_s \tag{2.32}$$

to be valid. It is the purpose of this paper to study the basic electromagnetic properties of the PAB.

A new class of impedance boundary has been identified as perfect anisotropic boundaries (EBP) based on the classification of two-dimensional binary algorithms. It has also been proposed to use a PAB grip in the form of a pitched metamaterol plate. In addition to the properties of the EBP, the bilateral wave reflection and polarization transformation are described in the presence. The transformation of polarization is a natural feature on the face of the EBP. By correctly selecting the ABB over-support, each value can be continuously changed by rotating the EBP structure in a linear polarization area, which can be transformed into an elliptical polarization field with an axial and manual ratio Since any elliptical polarization can be converted into linear polarization in the same way, it can become any other elliptical polarization after it is reflected on the face of another EBP. Another interesting feature of the EBP area is two symbols that support a surface wave. Surface waves are limited to diffusion on the surface of two sectors, while two of the other two sectors are improving. In contrast, the condition of the conditional impedance supports all aspects of wave and wave spreading waves. This property creates some interesting applications when designing the antenna. For example, as two surface waves are orthogonally polarized, the polarization of radiation from the surface wave antenna can be altered by rotating in the nutrient structure. Properties similar to the wavelength section can also be applied.

2.5. MIXED IMPEDANCE BOUNDARY CONDITIONS

It is known, in welding and isotropic media, when polar particles TE and TM enter any fixed space outside any area from any source, it can be divided into several parts.[15] Depicting the situation, we can numerically state;

$$E = E_{TE} + E_{TM}, \quad H = H_{TE} + H_{TM} \tag{2.33}$$

$$\boldsymbol{u}_z . E_{TE} = 0, \quad \boldsymbol{u}_z . H_{TM} = 0$$

The decomposed fields satisfy individually the Maxwell equations

$$\nabla \times E_{TE} = -jk\eta H_{TE}, \qquad \nabla \times H_{TE} = j(\frac{k}{\eta})E_{TE}$$

$$\nabla \times E_{TM} = -jk\eta H_{TM}, \qquad \nabla \times H_{TM} = j(\frac{k}{\eta})E_{TM}$$

$$k = \omega\sqrt{\mu \in}\,, \quad \eta = \sqrt{\frac{\mu}{\in}}$$

and the divergences of the four vectors vanish. From these we obtain the following relations

$$\boldsymbol{u}_z\,.(\nabla \times E_{TE}) = -jk\eta\boldsymbol{u}_z\,.H_{TE} = -jk\eta\boldsymbol{u}_z\,.H \tag{2.34}$$

$$\boldsymbol{u}_z\,.(\nabla \times H_{TE}) = -j(\frac{k}{\eta})\boldsymbol{u}_z\,.E_{TE} = j(\frac{k}{\eta})\boldsymbol{u}_z\,.E \tag{2.35}$$

where one should pay attention that, in the last terms, the total fields are involved. The recent involvement of public spaces in the region needs to be addressed. Let us now consider a new type of electromagnetic field where one impedance limit conditions are valid for EM fields and TM. At the border of the aircraft z = o, isotropic half space should satisfy the field component of the field at z> 0 [17].

$$E_{TE} = Z_{TE}\boldsymbol{u}_z \times H_{TE} \tag{2.36}$$

$$E_{TM} = Z_{TM}\boldsymbol{u}_z \times H_{TM} \tag{2.37}$$

Of course, in this case, the boundary face impedance appears to be a regular isotropic barrier limit. Equation now can also be written as

$$H_{TM} = -\frac{1}{Z_{TM}}\boldsymbol{u}_z \times E_{TM} \tag{2.38}$$

Operating this by $\boldsymbol{u}_z.\nabla \times$ and applying 9 we obtain

$$\boldsymbol{u}_z \,.\, (\nabla \times (E_{TE} - Z_{TE}\boldsymbol{u}_z \times H_{TE}))$$
$$= -jk\eta\boldsymbol{u}_z \,.\, H_{TE} + Z_{TE}\nabla \,.\, (\boldsymbol{u}_z\, (\boldsymbol{u}_z \times H_{TE})$$
$$= -(jk\eta - Z_{TE}\partial_z)\, \boldsymbol{u}_z \,.\, H = 0$$

At the terminal working step, we have applied $\nabla . H_{TE} = 0$, Similar actions lead to similar outcomes. The following limit conditions are therefore for the normal component of the common area.

$$jk\eta\boldsymbol{u}_z \,.\; H - Z_{TE}\partial_z\boldsymbol{u}_z \,.\; H = 0$$
$$jkZ_{TM}\boldsymbol{u}_z \,.\; E - \eta\partial_z\boldsymbol{u}_z \,.\; E = 0$$

All TE and TM elements are valid when considering the boundary as the limit of the obstruction. However, randomized TE and TM are simple to show the equivalence of polar waves in the air.

The boundary conditions on forms (15), (16) appear to be more general, regardless of the TM / TM split, and may be referred to as mixed impedance boundary conditions (MI). The IS boundary is an isotropic boundary condition as there is no border advantage, but this isotropy should not be confused with an isotropic conventional obstructive surface. This demonstration is based on the decomposition of TE and TM, by (15), (16) which has no meaning for the field, which cannot be identified in areas belonging to TE and TM parts, ie areas that respect VAW. Airlines, usually borderlines, are an example of such a region. However, as in the WB or BD boundary [19], the marginal conditions of these special fields are inadequate and additional situations are needed where the physical reality of the mathematical boundaries can be found. The reality of finding EU boundaries should remain the subject of future business. However, it is known that local sources cannot create TEM fields, so the problem of loneliness is limited to endless sources.

2.6. TYPES OF ANISOTROPIC IMPEDANCE BOUNDARY CONDITIONS

The most common impedance conditions are binary drug content in four border coordination systems and four scalar parameters. As a special case the limit of impedance may be specified as follows.

- Isotropic impedance boundary; $\overline{\overline{Z_s}} = Z_S\overline{\overline{I}}$
- Perfect electric conductor (PEC); $\overline{\overline{Z_s}} = 0$
- Perfect magnetic conductor (PMC); $\overline{\overline{Z_s}}^{-1} = 0$
- Perfect electromagnetic conductor (PEMC) [35]; $\overline{\overline{Z_s}} = Z_S\boldsymbol{n} \times \overline{\overline{I}}$
- Self-dual impedance boundary with [31]; $\overline{\overline{Z_s}} = Z_S(\boldsymbol{\alpha uu} + \boldsymbol{\alpha}^{-1}\boldsymbol{vv})$ with $\boldsymbol{u} \,.\, \boldsymbol{z} = \boldsymbol{0}$
- Soft-and-hard surface, previous case with [27], [28-30]; $\alpha \to 0$

The boundary conditions were recently considered on the basis of the components of the normal field, and two DB boundary conditions and DB-B boundary condition conditions were considered.

$$\boldsymbol{u}_z \,.\, D = 0, \quad \boldsymbol{u}_z \,.\, B = 0$$

And

$$\partial_z\boldsymbol{u}_z \,.\, D = 0, \quad \partial_z\boldsymbol{u}_z \,.\, B = 0$$

The WB was provided by Rumsey in 1959, but the application is only available in the near future. The Planar WB boundary acts as a PEC aircraft on the ground and is polarized in the TM area and is associated with the PMC. The purpose of this paper is to investigate many common boundary conditions and describe the conditions of individual boundary barriers for TE and TM components. Using Huygens equivalence principle to promote the real problem of waste is to create a new question: What borderline conditions are characterized by the S surface? An equivalent source of Huygens boundary is usually unknown (as with the true meaning of meaning), so that some physical information and data from the original siphon should be used to explain the problem.

We are well aware that the IBC can also be written in the following scrutinized form [3].

$$E_T = -\overline{\overline{Z_s}}\,.\,\hat{n} \times H, \; -\hat{n} \times H = \overline{\overline{Y_s}}\,.\,E_T \tag{2.39}$$

The area of the Zs is binary impedance and S = Z-1s is a normal vector of the surface of the binary surface and the impedance of n-plane.

$$\hat{n}\,.\,\overline{\overline{Z_s}} = \overline{\overline{Z_s}}\,.\,\hat{n} = 0, \quad \hat{n}\,.\,\overline{\overline{Y_s}} = \overline{\overline{Y_s}}\,.\,\hat{n} = 0 \tag{2.40}$$

The simplest form of the impedance limit is the isotropic boundary, which means the shape of the impedance which is stated as follows

$$\overline{\overline{Z_s}} = Z_s \overline{\overline{I_t}} \;, \quad \overline{\overline{Y_s}} = Y_s \overline{\overline{I_t}}$$

where $\overline{\overline{I_t}} = \hat{u}\hat{u} + \hat{v}\hat{v}$ is the unit dyadic tangential to the surface, and Ys = 1/Zs. The unit vectors ˆu and ˆv are local orthogonal tangential vectors on the surface, so that $\hat{u} \times \hat{v} = \hat{n}$.

2.7. PEC BOUNDARY CONDITION

The boundary condition of the PEC believes that the conductance of the given material is undefined, that is why the relating impedance dyadic is $Z_s = 0$. On the similar note, one can also define the (PMC) which is the perfect magnetic conductor's boundary area condition by the following formula

$$\hat{n} \times H = 0 \tag{2.41}$$

Similarly, as in the case of the PEC boundary, the admittance dyadic for the PMC surface is $Y_s = 0$. The below figure demonstrates the PEC surface.

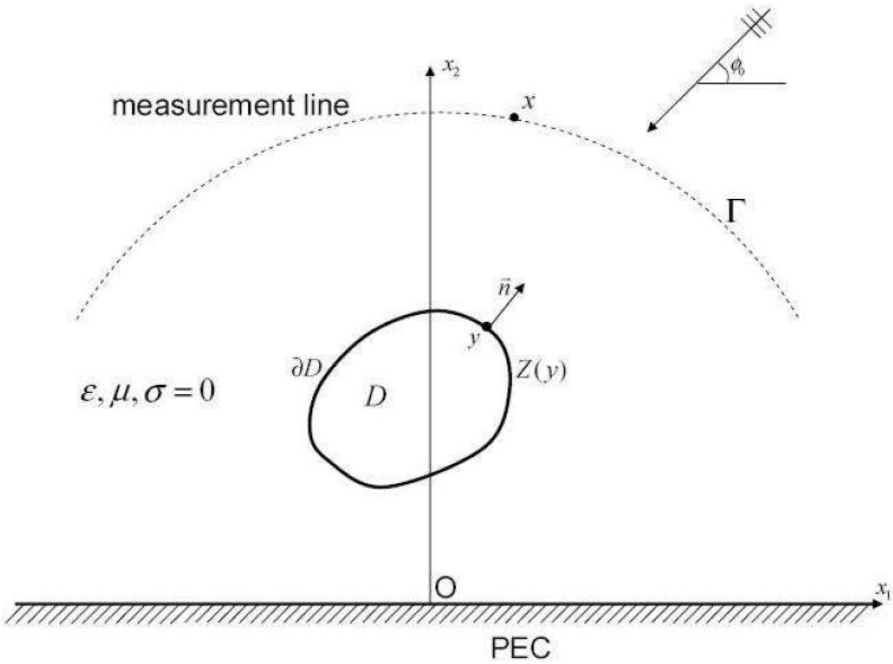

Figure 2.4. An Object with Inhomogeneous Surface.

PART 3

ELECTROMAGNETIC SCATTERING FROM ANISOTROPIC IMPEDANCE

3.1. ELECTROMAGNETIC SCATTERING FROM ANISOTROPIC SURFACES

Electromagnetic waves are one of the most common and most commonly encountered images of radiation exposed to scattering [44]. Particularly important is the scattering of light and radio waves, especially radars. For common names, many different aspects of electromagnetic scattering are completely different. Electromagnetic scattering is common in various objects [45]. This study is common problem in electrical engineering. If there is a dispersion problem including many scatters in an electromagnetic field, then, in some areas, it is necessary to separate the internal and external areas of the surface. For one purpose, if the structure of the light scattering surface is rather complex, it may be very difficult to solve the dispersion problem. This scab is frequently scattered the problem, for example, is a hollow surface of different lines Sugar, fractal surface, planar antenna structure, composite Combined, many meta-materials, and so on.

The properties of anisotropic material, such as a large module, vary throughout the building. The most common examples of anisotropic materials are wood and composites.

Anisotropic material are materials that depend on orientation.[47] The different complex anisotropic surfaces are shown in Fig. 7. It does not differ Isotropic materials have the same properties in all directions. Anisotropy possess material characteristics (such as young modules) vary by object. Common examples of anisotropic materials are wood and composite materials. Therefore, important physical characteristics of anisotropic materials are important to affect the behavior of the materials. For example, if there is a fracture Mechanism is a way in which microstructure of a material is directed Comment [HRM1]: The material is rigid in different directions and in the direction of the crack development.

Anisotropic materials are used in many areas of physics and technology. Some examples are magnetic anisotropy where the magnetic field shows in one direction. Anisotropic heat transfer, desired direction, geometry or dependence anisotropic material. Anisotropic materials are also the result of production rolling process or deep drawing. Composite materials and other materials
used and modified for special applications.

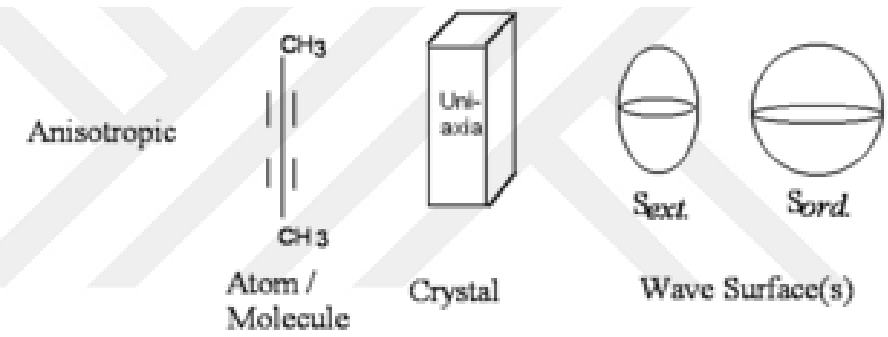

Figure 3.1. Different complex anisotropic structures.

In the dispenser area, this will simplify many scattering problems. Really complex surface structure can be simulated with boundary conditions. Then the problem of wasting only needs a lighter and simpler place and offers more efficient numerical solution. But the boundary state is mathematical idealization a complex situation, not a discovery that suits this problem Hard task. Consider many factors that he or she wants Such an estimate: the original curve of inclination, Depth of influence, nature and direction of the event area, Fortunately, many types of surfaces have impedance. The boundary conditions are fairly accurate. But find out Good edge conditions are usually just the first step Solve the problems you have learned. But it is not enough to just offer a numerical solution. There is no question to check the accuracy. Additionally, one must double-check when finding a possible application of your complex border conditions synthetic materials precisely produce any border conditions scatter behavior. In many cases, it means learning a complete, accurate model of the original complex surface structure. The surface may be problematic because it has too much tension Fine details, so accurate modeling should be practical accounts resources.

The Impedance Border condition (IBC) determines the relationship between them Harmoniousness when touching surfaces in electrical and magnetic fields. One needs to begin with an investigation to explore the relationship between these areas. Maxwell Equation in Frequency Area (Bundled) Time Factors $e^{-i\omega t}$.

$$\nabla \times \boldsymbol{E} = i\omega \boldsymbol{B} \tag{3.1}$$

$$\nabla \times \boldsymbol{H} = -i\omega \boldsymbol{D} + \boldsymbol{J} \tag{3.2}$$

$$\nabla . \boldsymbol{B} = 0 \tag{3.3}$$

$$\nabla . D = \rho \tag{3.4}$$

Due to frequent symmetry reasons, the flux density is adjusted to M regulation

$$\nabla \times \boldsymbol{E} = i\omega \boldsymbol{B} - \boldsymbol{M}$$

Introduction of magnetic charge density into the equation,

$$\nabla . B = \rho m$$

Maxwell's equation involves two vectors and two scalar equations, and four vectors are not known. To this end, a unique solution is provided Field, middle equation (i.e. constructive relation) was introduced. We can write a common form

$$\boldsymbol{D} = \bar{\bar{\varepsilon}} \boldsymbol{E} + \bar{\bar{\in}}\, \boldsymbol{H}$$

$$\boldsymbol{B} = \bar{\bar{\boldsymbol{\varsigma}}} . \boldsymbol{E} + \bar{\bar{\mu}} . \boldsymbol{H}$$

For a linear environment, diode dielectric depends on the parameters $\bar{\bar{\varepsilon}}, \bar{\bar{\boldsymbol{\varsigma}}}$, μ about electrical and magnetic properties of media. Media settings mask all physical events in the media and macro electromagnetic field acts as two different media. One may have the appropriate media, even if you have the same media settings, it has different physical properties.

3.2. TYPES OF ELECTROMAGNETIC SCATTERING

Scattering is a common physical process that is forced by some form of radiation, such as light, sound or moving particles, to go beyond the straight path of one or more pathways due to the average local differences that they experience. According to normal use, this implies that the radiation reflects beyond the legitimate angle. Electromagnetic waves are one of the most common and most commonly encountered images of radiation exposed to scattering. Particularly important is the scattering of light and radio waves, especially radars. For common names, many different aspects of electromagnetic scattering are completely different. The basic shape of elastic light scattering (with a small amount of energy transfer), electromagnetic scattering is a process in which a particle in the path of an electromagnetic wave. Permanently releases energy from the event wave and re-distributes the energy. Along with the acquired or diffused, electromagnetic radiation is dispersed with particles in the atmosphere. Spraying method is the redistribution of electromagnetic energy by the stable particles in the atmosphere. The type and amount of wastes depends on the size of the particles and the wavelength of energy.

The general solid angle in which the particles are centered; there are two types of electromagnetic scattering:

- Scattering from Soft Surface
- Scattering from Hard Surface

3.2.1. Scattering from Soft Surface

In this type of scattering, initially, the elasticity of light or other electromagnetic radiation diffuses into smaller particles than the radiation wavelength. The collapse does not change the state of the material, and therefore is a parametric process. Fibers can be a single atom or molecule. When the light is transparent and passes through liquids, the most visible light becomes visible in the gas. Electromagnetic scattering is the result of polarity of electrical particles. The electric field of the light wave affects the accusations in particles and causes the same rate of movement. Therefore, the particle turns into a small air dipole, which is considered to radiate radiation. This radiation is a component of the photo and is not an excitement.

Following equation is used to calculate the size of the scattering particle:

$$x = \frac{2\pi r}{\lambda}$$

It has a characteristic length (radius) and a wavelength λ of light. The diffused light amplitude diffused from any transparent dielectric is proportional to the inverse square and the volume of the wavelength, i.e. Wavelength dependence is characteristic of dipole dispersion, and the volume dependence is applicable to any scattering mechanism.

3.2.2. Scattering from Hard Surface

When light reaches the surface of a hard object, the light does not leave the place in a certain direction, but spreads over wide angles in many directions. This is especially applied to surfaces such as white hard surfaces. These leaks are most common when the light on the normal physical non-transparent objects is turned on. When the visible light threatens ordinary daily physical non-transparent objects, the splash is most commonly used.

The problem of electromagnetic scattering in the region of a hard and larger diameter is mainly solved by Gustav Mie, and the area scattered on Rayleigh's range is called Mie scattering. In the scattering from hard surface, the shape of the scattering center is very important, and the theory is most suitable for the regions and some variations, spheres and ellipsoids. In some simple forms, there is a closed solution for wasting, but there is no solution for the basic form. Both types of electromagnetic scattering are both elastic scattering processes, meaning that light energy (hence the wavelength and frequency) does not change substantially. However, electromagnetic radiation dissipated by the motion-injection center can be used to measure the dispersion rate of the center in the form of a technique such as laser radar and radar with Doppler shift. This change is a small change in energy. In particle sizes of more than 10 wavelengths, the laws of geometric optics are sufficient to describe the interaction of light with particles, and interactions at this point are generally not described as dissipation.

3.3. OVERVIEW OF A PEC (PERFECT ELECTRIC CONDUCTOR) SURFACE

The perfect electronic conductor (PEC) is ideal for infinite or even zero resistance (e.g. Perfect Dielectric). Although perfect electronic rays are not inherent, this concept is a useful model when resistance is negligible compared to other effects. An example is the perfect magneto hydrodynamic study of excellent conductive fluids. Another example is a motor diagram that connects components without any resistance. An example of a PEC surface is shown in Figure 8.

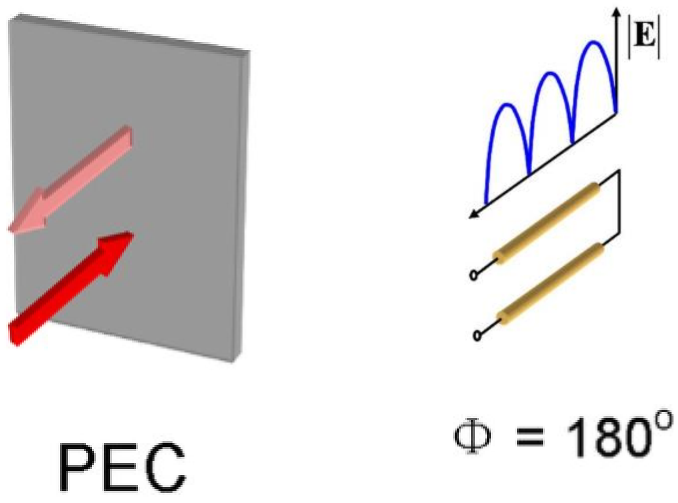

Figure 3.2. Demonstration of scattering through a PEC surface.

Another example is the electromagnet of an electromagnetic measuring instrument, where PEC can be simulated faster because the PEC components of the subsequent conductivity calculation are ignored. Following are the important properties of perfect electric conductors:

- With a precise resistance to zero - a steady stream of energy at an ideal show flows without loss of energy. Resistance causes the consciousness to warm up, as the perfect show cannot create heat. As the energy does not lose heat, the power will not be strengthened, and to a potential difference, it will last forever in perfect transmitters.
- The constant magnetic flux is needed - the magnetic flux inside the ideal beam should change over time. Any external areas applied to the perfect guide will not affect the internal configuration.

Perfect electric conductors are immensely different from the superconductors. In addition to electrical resistance, superconductors show quantum effects such as the Meissen effect and the magnetic flux quantization. On the other hand, the perfect electric conductor should maintain the constant of the internal magnetic field, but it can have a zero or zero value. In real superconductors, the excess (Meissen effect) removes all the magnetic flux during phase transitions, and in most super alloys, the magnetic field is always zero. Orthogonal electric field exists on the surface of a perfect electric conductor. In an ideal conductor, resistance is ideally zero. This flow will continue when the power is removed. In a simple conductor, the current resistance is switched off when power is turned off. When the supersonic phase continues, the superconductor becomes zero. The perfect conductor or perfect electric conductor (PEC) is an ideal material with infinite conductivity or zero resistance (ideally perfect dielectric). Although there is no perfect behavior in nature, the concept is a useful model when the resistance is insignificant compared to other influences. The process continues even if the power is removed. However, the difference between the ideal and the superconductor shows the effect of the superconductor Meissner. When they say they have put the conductor in the magnetic field, magnetic forces pass through the emitter. When it is transferred to the phase of the superconductor, it is removed from the magnetic field when it is cooled below the critical temperature. That's the influence of Meissner. The superconductor shows the effect of Meissner, and the ideal performance does not affect Meissner.

The boundary conditions at the surface of a perfect electric conductor are due to the equation of Faraday's law. This is the tangential component of the electric field Continuous on the surface requires a zero-electric field in a perfect electric field. The conductor reports that the electric field on the perfect iron surface can only be vertical for that. The surface then supports a surface load density $\sigma = 0E\perp$.

$$E_{||} = 0,\ B_{\perp} = 0 \qquad \text{(PEC)}$$

The normal component of B's magnetic field is resistant to any surface $\nabla \cdot B = 0$), in the sense that the ideal magnetic field is zero, Magnetic field on the surface of ideal mind can only be a tangent component. The perfect border management (PEC) for power management.

Although the concept of "the perfect electric conductors" is used by the engineering community. However, it is a formal contradiction; its use is usually limited to the surface in a vacuum, describes the electromagnetic field on one side of the surface. With this limitation, the use of "perfect electric conductors" (around) can give reliable results; just for the current instant example. A perfect electric conductor has all the concepts in the field of zero electric field. The internal magnetic field depends on the time (on the other side of the road). In the "classic" field of electrodynamics, this is original conditions do not cover inadequate energy, perfect internal magnetic fields, the conductor is also zero. The ideal conductor should maintain the constant of the internal magnetic field, but it can have a zero or zero value. In real superconductors, the excess (Meissner effect) removes all the magnetic flux during phase transitions, and in most super alloys, the magnetic field is always zero.

3.4. ELECTROMAGNETIC SCATTERING ABOVE PEC SURFACE

The perfect electromagnetic instruction is a tool that features special features. Although very simple, this electromagnetic four-dimensional formula is most clearly seen in the PEC concept is a new discovery. Conventional electromagnetic engineering symbolic representation, the four parameters of the material are ever growing, have a magnetic connection and are unresponsive. The PEC 4D is a complete isotropic of space and time, thanks to its connectivity components and the shuttle is a two-way isotropic. Due to the short-term features of the signal, electrical and linear combination, the electric field, the PEC material, provides media for microwave technology application. Potential samples, such as boundaries, such as thin antenna floors, Antenna arrays, polarization transformers, radar reflectors and common area cleaners, High Impedance Surface. The boundary surface is a conceptual two-dimensional structure, an induction of an electromagnetic source External areas are combined with some internal mechanisms. As a source, we can get electricity Magnetic surface current, electric and magnetic surface filling. The normal vector e_3 on the boundary surface and the boundary area are bound to it. Surface welding conditions

$$e_3 \times \boldsymbol{E} = -\boldsymbol{J}_{ms}$$
$$e_3 \times \boldsymbol{H} = \boldsymbol{J}_{es}$$
$$e_3 \, . \, \boldsymbol{D} = \varrho_{es}$$
$$e_3 \, . \, \boldsymbol{B} = \varrho_{ms}$$

For simple and fixed unit vectors, e_1, e_2, e_3, the boundaries of the orthogonal plane

Key. The source refers to sustainability, treating the harmonic time field as exp (jōt), depending on the time of scattering

$$\nabla \,.\, \boldsymbol{J}_{es} \;=\; -\boldsymbol{j}\,\boldsymbol{\omega}\,\varrho_{es}$$
$$\nabla \,.\, \boldsymbol{J}_{ms} \;=\; -\boldsymbol{j}\,\boldsymbol{\omega}\,\varrho_{ms}$$

Following the Maxewell's equation,

Major electromagnetic scattering problems cover PEC boundaries. Problems surrounding PEC boundaries in the vacuum may be problems with PEC restrictions and may be analyzed by well-known techniques. Perhaps the most different one; the plane is a rotation of the linear polarization correction wave boundary of the PEMC surface impact Reflection. This is a normal incidence in Figure 1. It is necessary to note the same event Reflection rotation also occurs with hair appearance. In addition to M, the alternative amount of the PEMC environment passes through the second parameter, the rotation angle (Figure 3.4) in the absence of the parameter θ simply merges: β = π - 2θ.

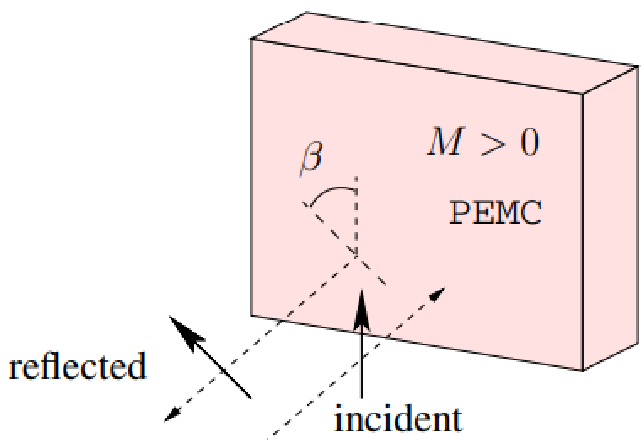

Figure 3.3. An electric field reflecting the waves of linear polarized aircraft Polarization caused by PEC media. Open β. M, the direction of rotation is in the direction of the clockwise direction (as shown in the wave of incident) Arctane (Mē0) angle β = 2, η0 is

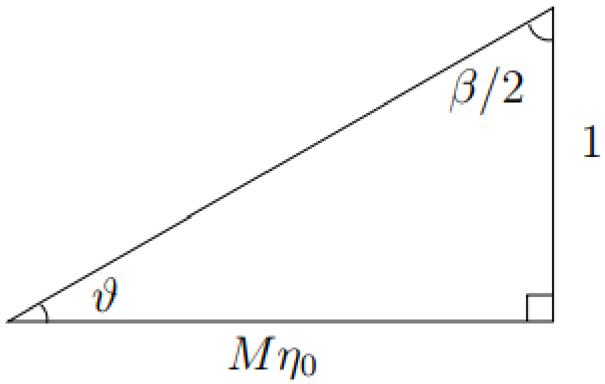

Figure 3.4. Combined geometric drawings with three parameters: PEC symbols M and θ, and angle of polarization rotation β It is reflected on the surface of the PEC aircraft in the direction of the aircraft.

Figure 10 shows the geometric relationship between the angle parameters. The particular circumstances of this problem are that there are PEC and PEC interfaces in the apartment. It is known that the reflection of a wavelength reflected by the ideal conductor is -1, 180 degrees rotation. This corresponds to the general results above (PEC = 0, B = π).

$$\cot\vartheta = \ M\eta 0$$

In addition, PEC results are consistent (π = π / 2, rotation 0). paying attention to the general Value, reflection, non-interaction phenomenon. This is reflected in the following observations: If In Figure 1, the event area is substituted by one opposite area (in other words, nose β is rotated) The reflection will turn in one direction in contrast to the direction of the clock, and the opposite area will not appear Original event area. This effect resembles Faraday's lack of interaction in the ionosphere.

In addition to the polarization effects of small PEC surfaces, diffraction and dissipation can be analyzed by evolutionary barrier, applying the "Full Wave Scale Method-Moments" surface integral equation to the "common" boundary conditions of the PEC type. An example image; The characteristics of small PEC regions and devices in relation to wavelengths are described. The field electric field is ka = 2πa / λ = 3, which is already very large Radiations and minimum waves are caused by a scattering mode. Figure 1,2 have two examples. : E-plane dispersion (direction of wave propagation and plane defined by the electric field vector), H splitting (direction of propagation and magnetic field) and cross polarization Disintegration (at the same level). However, PEC fields are not transversely polarized the image shows a very strong cross polarization in the general PEC region, in the direction of withdrawal. According to the analysis of the aircraft, this is intuitive.

3.5. ELECTROMAGNETIC SCATTERING FROM ANISOTROPIC INHOMOGENEOUS IMPEDANCE CYLINDER OF ARBITRARY SHAPE ABOVE PEC SURFACE

Examining the behavior of the anisotropic inhomogeneous impedance cylinder and disperse their perfection [49]. The body is coated with a complex layer. Consider the complex layers as a uniform surface of a cylindrical arbitrary as shown in Fig.11. Currently, frequency selective surfaces are important for the design of artificial covers. There are two important ways to solve Maxwell's equations in harmonic mode. The first method is a volume method. Find their calculations Interior and exterior objects of different sizes. It uses the domain name Limit barriers to artificial boundaries. By considering physical characteristics Media, especially anisotropic effects, should only be used in large quantities unknown and open border management. Considering the boundary conditions of an anisotropic inhomogeneous impedance cylinder, a set of integral equations defined on the surface of a barrier. But they can only be applied to similar objects [51]. We can use them three Dimensional and two-dimensional domains. The boundary conditions of high impedances have recently been studied. [R-Sb, R-Sa]. These conditions take into account the angle of the events at each point Surface of the tangential component and surfaces and the number of transverse waves. The Border Impedance Treaty (IBC) determines the relationship between them Harmoniousness when touching surfaces in electrical and magnetic fields. It is important to begin with an investigation to explore the relationship between these areas of the Maxwell equations.

The Numerical results for two-dimensional cylinder with and without lossless media Color and three-dimensional revolutionary entities, Solved systemic problems

Tangential electric E and magnetic field H. The impedance operator approached the ratio and Different operator polynomials

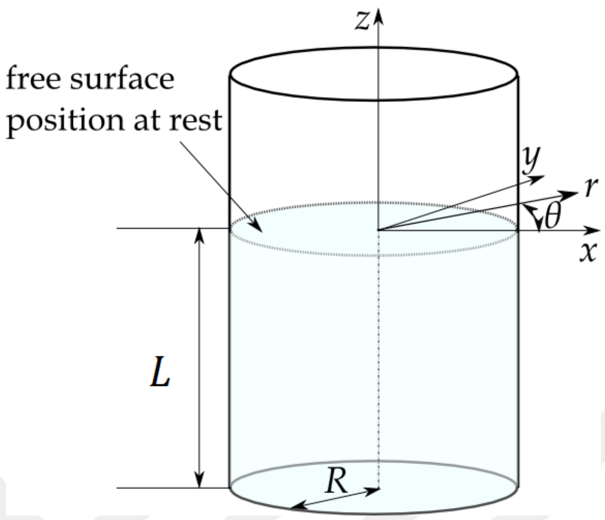

Figure3.5. Cylinder of arbitrary shape.

give boundary conditions as an equation to these polynomials. This is called high level IBC (HOIBC). First and second class HOIBCs are described for two-dimensional state. Using a different operator, a first-class IBC for a three-dimensional work is offered.

At each point on the surface, the impedance is considered an impedance of infertility, planetary layer. Different points of event waves have different angles surface. We still have boundary conditions under constant conditions. It is taken into account that the event deficit has changed. Consider the isotropic plane the normal z-direction n (x, y) is an environment that has a native orthogonal core (x, y, z) at a natural plane when the line is flat. The precise impedance is followed

$$Z_{xy}(k_x, k_y) = Z_{yx}(k_x, k_y) \ = \ i\sqrt{\frac{\mu}{\varepsilon}}\,\frac{k_x\,k_y}{k\,k_z}\,\tan[k_z d]$$

$$Z_{xx}(k_x, k_y) \ = \ -\,i\sqrt{\frac{\mu}{\varepsilon}}\,\frac{k_x^2 k_z^2 + k_y^2 k^2}{k\,k_z(k_x^2 + k_y^2)}\,\tan[k_z d]$$

$$Z_{xx}(k_x, k_y) \ = \ -\,i\sqrt{\frac{\mu}{\varepsilon}}\,\frac{k_y^2 k_z^2 + k_x^2 k^2}{k\,k_z(k_y^2 + k_z^2)}\,\tan[k_z d]$$

Z waveform is impedance tensor (kx, ky), frequency wave and cover every point on the surface.

The right wave field is written in the following form:

$$\mathbf{E}(\mathbf{r},\mathrm{t}) = \boldsymbol{e}_1 \mathrm{E}_0 \mathrm{e}^{-\mathrm{i}\mathbf{k}\,.\,\mathbf{r}+\mathrm{i}\omega\mathrm{t}}$$
$$\mathbf{H}(\mathbf{r},\mathrm{t}) = \boldsymbol{e}_2 \mathrm{H}_0 \mathrm{e}^{-\mathrm{i}\mathbf{k}\,.\,\mathbf{r}+\mathrm{i}\omega\mathrm{t}}$$

Where $\boldsymbol{e}_1$, $\boldsymbol{e}_2$ are two fixed real vectors, E_0, H_0 are complex amplitudes. The stability of space and time.

$$\mathbf{E}(\mathbf{r}) = \mathrm{E}_0 \mathrm{e}^{-\mathrm{i}(k_x\hat{\mathbf{x}}+k_y\hat{\mathbf{y}}+k_z\hat{\mathbf{z}})\,.\,\mathbf{r}}$$
$$\partial_{\boldsymbol{x}}\mathbf{E}(\mathbf{r}) = -\boldsymbol{i}\,\mathrm{k_x}\mathbf{E}(\mathbf{r})$$
$$\partial_{\boldsymbol{x}}^{\mathbf{2}}\mathbf{E}(\mathbf{r}) = -\boldsymbol{i}\,k_x^2\mathbf{E}(\mathbf{r})$$

By replacing components,

$$\partial_{\boldsymbol{x}} = -\boldsymbol{i}\,\mathrm{k_x}$$
$$\partial_{\boldsymbol{y}} = -\boldsymbol{i}\,\mathrm{k_y}$$
$$\partial_{\boldsymbol{x}}^{\mathbf{2}} = -k_x^2$$
$$\partial_{\boldsymbol{xy}}^{\mathbf{2}} = -\mathrm{k_x k_y}$$
$$\partial_{\boldsymbol{y}}^{\mathbf{2}} = -k_y^2$$

[R-Sb] use spectral recording impedance border conditions, domain method and secondary polynomial a Coating, rotation does not change. We can write about these equations Master,

$$(1+b_1\partial_x^2+b_2\partial_y^2)E_x+(b_1-b_2)\partial_{xy}^2E_y=(a_1-a_2)\partial_{xy}^2H_x-(a_0+a_1\partial_x^2+a_2\partial_y^2)H_y$$

and

$$(b_1-b_2)\partial_{xy}^2E_x+(1+b_2\partial_x^2+b_1\partial_y^2)E_y=(a_0+a_2\partial_x^2+a_1\partial_y^2)H_x+(a_2-a_1)\partial_{xy}^2H_y$$

Note that $\mathbf{n}\times\mathbf{H}=-H_y\mathbf{x}+H_x\mathbf{y}$. And HOIBC is written in matrix form

$$\begin{bmatrix} 1+b_1\partial_x^2+b_2\partial_y^2 & (b_1-b_2)\partial_{xy}^2 \\ (b_1-b_2)\partial_{xy}^2 & 1+b_2\partial_x^2+b_1\partial_y^2 \end{bmatrix}\begin{pmatrix} E_x \\ E_y \end{pmatrix}=$$
$$\begin{bmatrix} a_0+a_1\partial_x^2+a_2\partial_y^2 & (a_1-a_2)\partial_{xy}^2 \\ (a_1-a_2)\partial_{xy}^2 & a_0+a_2\partial_x^2+a_1\partial_y^2 \end{bmatrix}\begin{pmatrix} -H_y \\ H_x \end{pmatrix}$$

Electromagnetic (EM) scattering analysis of an anisotropic inhomogeneous structure that contains complex media Meta-material, anisotropy, bidirectional anisotropy Centered and non-uniform media, its complicated structure, has always been one of the most exciting topics for researchers. In addition, due to the application of non-uniform flat and cylindrical structures, this environment may be used in wind structures.

This can potentially lead to exciting applications. Approximate method for analysis of Electromagnetic fields are sprung off of informal areas. The vacuum is smaller than the wavelength. Describing different equations implement the Electromagnetic scattering on an on-going basis. This direction is entirely from the Maxwell equation. To resolve the problems of the equation. The problem of dual aircraft is simpler than ever before to solve and utilize. The proposed duality is based on the equivalence of the proposed evolution and wave differential equation in the boundary condition. The key elements for solving the problem are two structures of any electromagnetic problem. Check the reliability of the proposed duality in the special case mentioned analytically, there is a clear solution. It is known that the structure of the anisotropic inhomogeneous boundary is heavy. It is important to use an insensitive environment in these structures. Increase the complexity of the problem. In addition, the E0 spreading in the positive direction gives a mathematical method for managing an electric field, illuminates the displayed structure.

PART 4

PROBLEM FORMULATION AND NUMERICAL ANALYSIS

The geometry of the considered scattering problem and parameters employed in the formulation are shown in Fig.12. The object defined by its boundary ∂D and inhomogeneous anisotropic surface impedance $\bar{\bar{Z}}(\vec{r}),\ \vec{r} \in \partial D$. This object is located above PEC surface defined as y=0. The exterior environment is taken to be medium with permittivity ε, permeability μ and lossless.

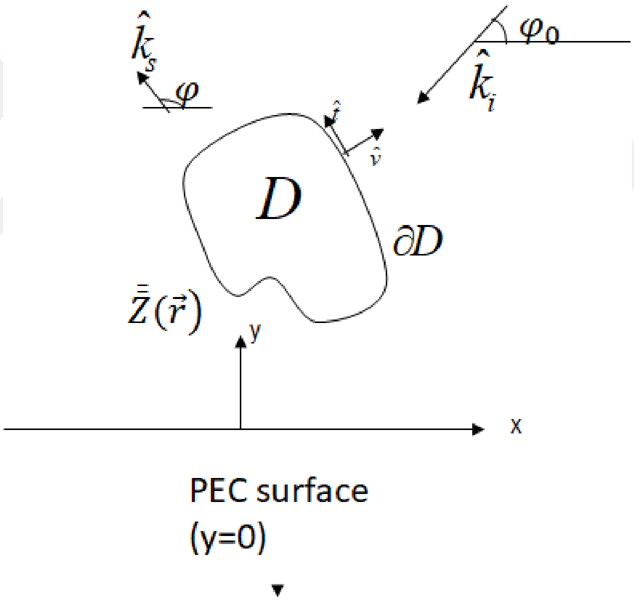

Figure 4.1. Geometry of the problem.

The cylinder is illuminated by monochromatic plane wave whose electric field is along z axis that corresponds to TM illumination of the form as,

$$\vec{E}^i(\vec{r}) = (0,0,E_z^i(\vec{r}))$$

$$E_z^i(\vec{r}) = e^{ik\hat{k}_i.\vec{r}} - e^{ik\hat{k}_i(\hat{u}_x\hat{u}_x - \hat{u}_y\hat{u}_y).\vec{r}} \tag{4.1}$$

or whose magnetic field is along the z axis that corresponds to TE illumination of the form as,

$$\vec{H}^i(\vec{r}) = (0,0, H_z^i(\vec{r}))$$

$$H_z^i(\vec{r}) = \frac{1}{Z_0}\left(e^{ik\hat{k}_i.\vec{r}} + e^{ik\hat{k}_i(\hat{u}_x\hat{u}_x - \hat{u}_y\hat{u}_y).\vec{r}}\right) \tag{4.2}$$

where $Z_0 = \sqrt{\mu/\varepsilon}$ is characteristic impedance of exterior medium and $\hat{k}_i = -cos\varphi_0\hat{u}_x - sin\varphi_0\hat{u}_y$ is the propagation direction of incident field with incidence angle φ_0 and, $k = \omega\sqrt{\varepsilon\mu}$ is the wave number of exterior region. Due to the homogeneity of the problem with respect the z-axis, partial derivative with respect to z is zero. Since boundary condition is anisotropic, the total field contains both TM ($E_z \neq 0, H_z = 0$) and TE ($E_z = 0, H_z \neq 0$) fields.

The TM and TE fields satisfy the reduced Helmholtz equation as

$$\begin{aligned} &\Delta E_z + k^2 E_z = 0 \\ &\Delta H_z + k^2 H_z = 0 \end{aligned} \tag{4.3}$$

and the inhomogeneous anisotropic IBC [9,10],

$$\hat{v}(\vec{r}) \times (\hat{v}(\vec{r}) \times \vec{E}) = -\bar{\bar{Z}}(\vec{r}).(\hat{v}(\vec{r}) \times \vec{H}(\vec{r})), \quad \vec{r} \in \partial D \tag{4.4}$$

and radiation conditions as

$$\lim_{r\to\infty}\sqrt{\rho}\left(\frac{\partial E_z^s}{\partial\rho} - ikE_z^s\right) = 0, \quad \rho = |\vec{r}| \tag{4.5}$$

$$\lim_{r\to\infty}\sqrt{\rho}\left(\frac{\partial H_z^s}{\partial\rho} - ikH_z^s\right) = 0, \quad \rho = |\vec{r}| \tag{4.6}$$

where $\hat{v}$ is unit normal vector on ∂D, and $\bar{\bar{Z}}(r)$ is inhomogeneous impedance dyadic expressed as,

$$\bar{\bar{Z}}(\vec{r}) = Z_{vv}(\vec{r})\hat{u}_z\hat{u}_z + Z_{zt}(\vec{r})\hat{u}_z\hat{t}(\vec{r}) + Z_{tt}(\vec{r})\hat{t}(\vec{r})\hat{t}(\vec{r}) + Z_{tz}(\vec{r})\hat{t}(\vec{r})\hat{u}_z, \quad \vec{r} \in \partial D \tag{4.7}$$

where $\hat{t}(\vec{r}) = \hat{u}_z \times \hat{v}(\vec{r})$ is tangential unit vector on ∂D as depicted fig.1. As seen from (4.7), this is most general IBC and all kind of boundary condition discussed previously in literature can be expressed by appropriate choice of impedance functions. For example, if $\bar{\bar{Z}}(\vec{r}) = 0$, boundary condition described in (4.7) reduces to perfect electric conductor (PEC) condition. If $Z_{zt} = Z_{tz} = 0 and\ Z_{zz}, Z_{tt} \to \infty$, (4.7) reduces to perfect magnetic conductor (PMC).

If

$$Z_{zt} = Z_{tz} = 0 and\ Z_{zz}(\vec{r}) = Z_{tt}(\vec{r}) \neq 0,\ \vec{r} \in \partial D, \tag{4.8}$$

reduces isotropic inhomogeneous IBC which is discussed in (4.5,4.8).
Let's represent the fields on the boundary ∂D as

$$\vec{E}(\vec{r}) = E_v(\vec{r})\hat{v}(\vec{r}) + E_t(\vec{r})\hat{t}(\vec{r}) + E_z(\vec{r})\hat{u}_z, \quad \vec{r} \in \partial D \tag{4.9}$$

$$\vec{H}(\vec{r}) = H_v(\vec{r})\hat{v}(\vec{r}) + H_t(\vec{r})\hat{t}(\vec{r}) + H_z(\vec{r})\hat{u}_z, \quad \vec{r} \in \partial D \tag{4.10}$$

Substituting (4.9) and (4.10) into (4.4), one obtains boundary conditions as

$$E_t(\vec{r}) = Z_{tz}(\vec{r})H_t(\vec{r}) - Z_{tt}(\vec{r})H_z(\vec{r}), \quad \vec{r} \in \partial D \tag{4.11}$$

$$E_z(\vec{r}) = Z_{zz}(\vec{r})H_t(\vec{r}) - Z_{zt}(\vec{r})H_z(\vec{r}), \quad \vec{r} \in \partial D \tag{4.12}$$

By using Maxwell equations, one can obtain as,

$$H_t(\vec{r}) = \frac{i}{kZ_0}\frac{\partial E_z}{\partial v}(\vec{r}), \quad \vec{r} \in \partial D \tag{4.13}$$

$$E_t(\vec{r}) = \frac{-iZ_0}{k}\frac{\partial H_z}{\partial v}(\vec{r}), \quad \vec{r} \in \partial D \tag{4.14}$$

Substituting (4.13) and (4.14) into (4.9) and (4.10), one obtains

$$\frac{-iZ_0}{k}\frac{\partial H_z}{\partial v}(\vec{r}) = Z_{tz}(\vec{r})\frac{i}{kZ_0}\frac{\partial E_z}{\partial v}(\vec{r}) - Z_{tt}(\vec{r})H_z(\vec{r}), \quad \vec{r} \in \partial D \tag{4.15}$$

$$E_z(\vec{r}) = Z_{zz}(\vec{r})\frac{i}{kZ_0}\frac{\partial E_z}{\partial v}(\vec{r}) - Z_{zt}(\vec{r})H_z(\vec{r}), \quad \vec{r} \in \partial D \tag{4.16}$$

Now we can use these Maxwell Equations to find an accurate evaluation of the electromagnetic fields inside and outside a cylinder of an arbitrary shape with the object located above PEC surface.

$$\int_0^{2\pi} L_1(t,\tau)\Phi(\tau)d\tau + \int_0^{2\pi} L_2(t,\tau)\Psi(\tau)d\tau + \frac{iZ_{tz}(t)}{2kZ_0}\Phi(t) + \frac{iZ_0}{2k}\Psi(t) = f(r(t)) \tag{4.17}$$

$$\int_0^{2\pi} L_3(t,\tau)\Phi(\tau)d\tau + \int_0^{2\pi} L_4(t,\tau)\Psi(\tau)d\tau + \frac{iZ_{zz}(t)}{2kZ_0}\Phi(t) = g(r(t)) \tag{4.18}$$

Once the boundary integral equations (4.17) and (4.18) are solved the near and far fields of the TM. Let's call TM and TE fields as vertically (V) and horizontally (H) waves respectively. Polarimetric scattering width σ_{ab}, $a = H, V\,; b = H, V$is related to ratio of a polarized scattered power to $b$polarized incident power and defined by

$$\sigma_{ab}(\varphi) = \lim_{\rho\to\infty} 2\pi\rho \frac{|E_a(\rho,\varphi)|^2}{|E_b|^2}, \quad a = H, V\,; b = H, V \tag{4.19}$$

PART 5

RESULTS

5.1. CALCULATING THE BRCS

Here we calculate the bistatic radar cross section of five dielectric ($\epsilon r = 1.72{-}j0.0028q$, $q = 0,25,50,75,100$) and one PEC object on a cylinder of arbitrary shape with radiuses $R = 1$, for 361 θ between $[-\pi, \pi]$ and $\phi = 0$. The wavenumber is $k0 = 2\pi$, the magnitude of the incident plane wave is $E0 = 1$ and the expansion terms are 40. The results are illustrated in Figure 1

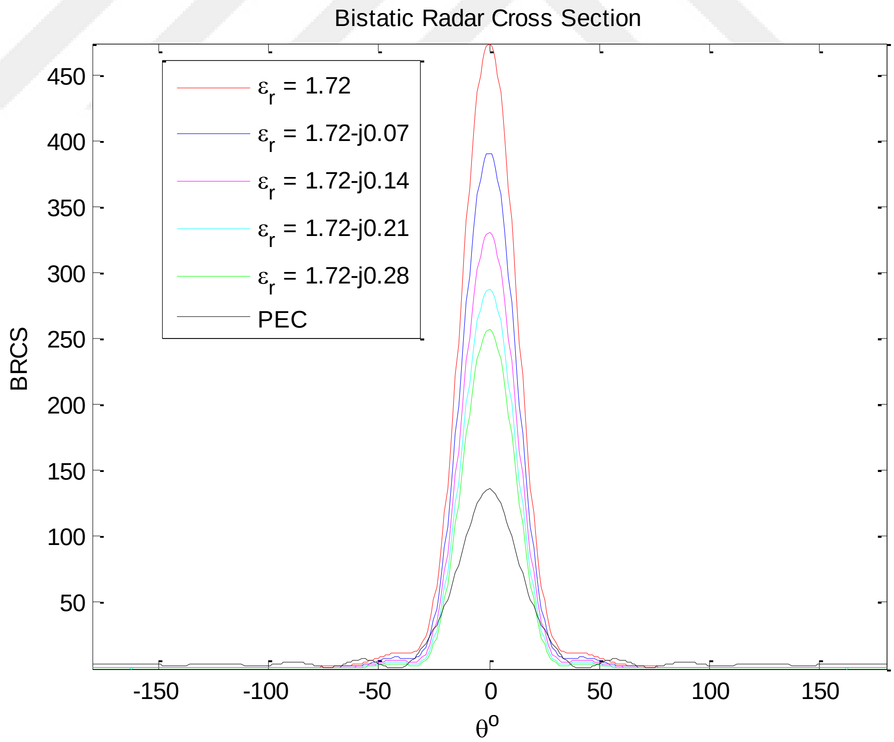

Figure 5.1. BRCS of the PEC surface with 5 dielectrics.

Now we calculate the monostatic radar cross section of one thousand PEC objects with radiuses linearly scales between 0.01m and 20m. The magnitude of the incident plane wave is E0 = 1, the wavenumber is k0 = 1 and the number of terms for the expansion is 40. The results are portrayed in Figure 2.

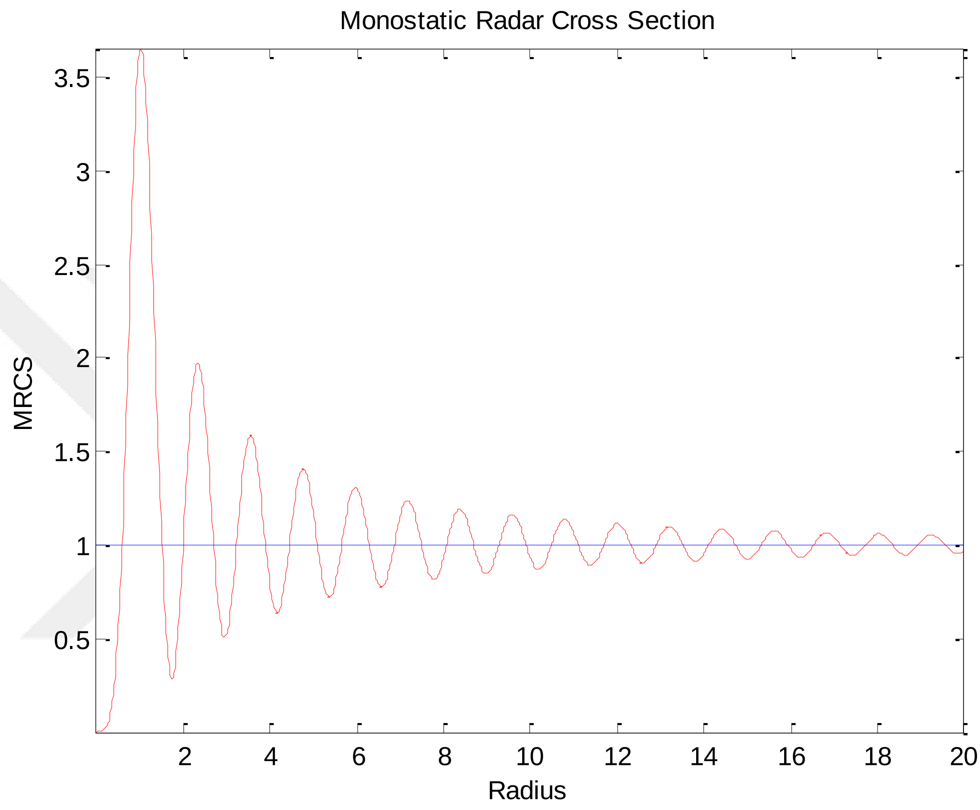

Figure 5.2. Cross-sectional radius of the PEC object.

5.2. MEASURING THE ELECTROMAGNETIC FIELD ON XYZ PLANE

Now we can measure the electromagnetic field on xx′ , yy′ and zz′ axis inside a dielectric sphere with radius R = 0.5 and relative permittivity $\epsilon r = 20 - j29.76$. The magnitude of the incident wave is E0 = 1, the wavenumber is k0 = 1 and the expansion terms are 10. The relevant figures are presented below

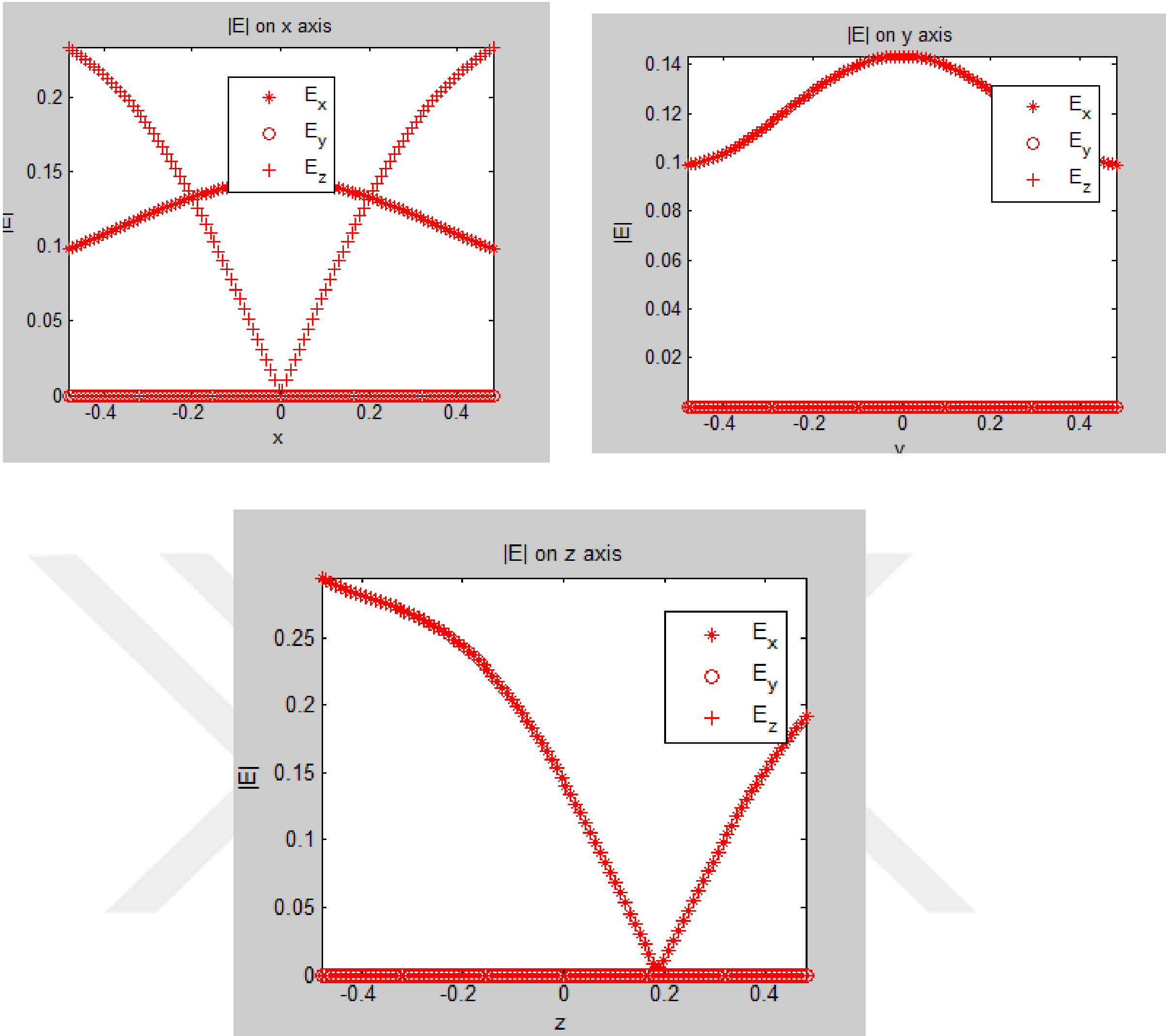

Figure 5.3. Electromagnetic Scattering across xyz plane of the PEC surface.

Similarly, for |H|

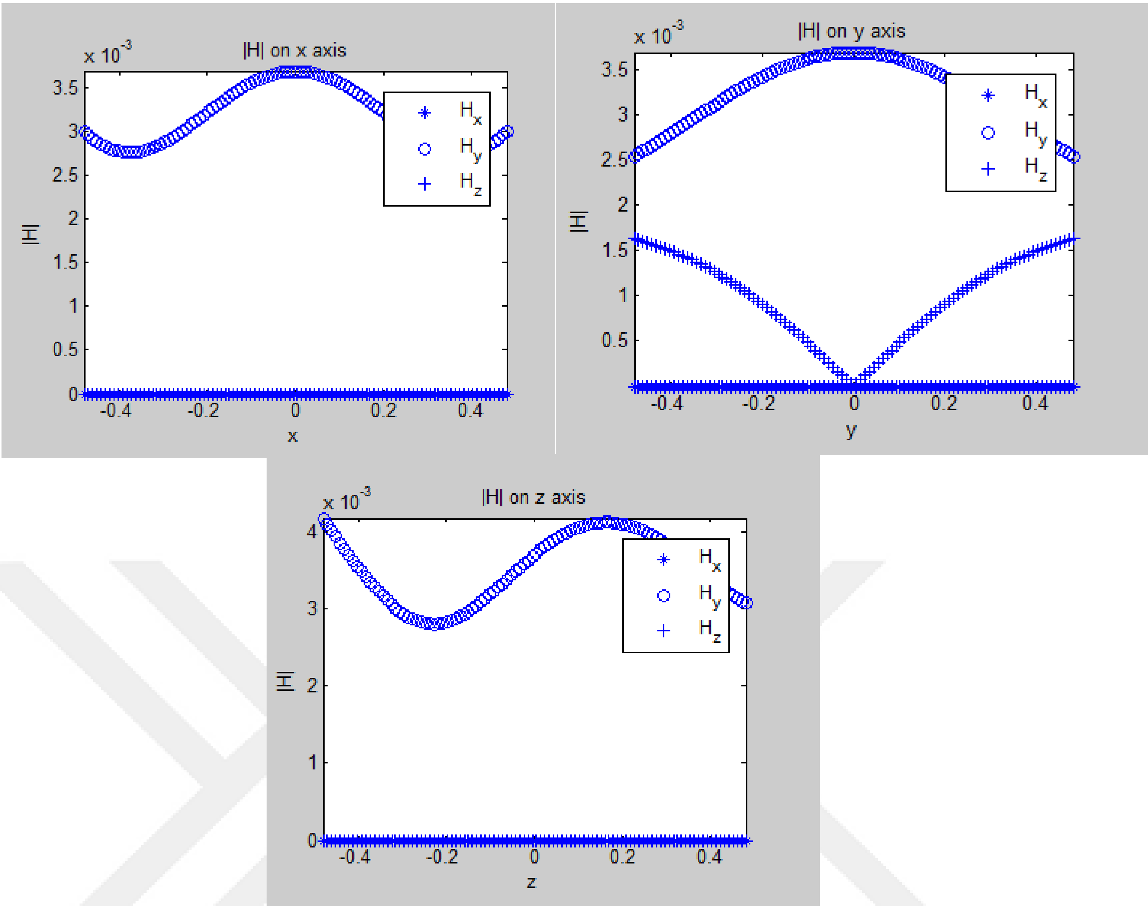

Figure 5.4. Magnetic scattering across xyz plane of the PEC surface.

Now to calculate the power efficiency,

we illustrate the scattering and absorption power efficiencies of a golden lossy nanoparticle with radius R = 1µm, µr = 1 and frequency-dependent permittivity.

$$\epsilon r = 1 - \omega 2 \ p \ \omega(\omega + j\gamma)$$

where {ωp, γ} = {1.37×1016 ,5.32×1013} rad s and ω = 2πf is the angular frequency. The calculations are implemented for 40 expansion terms and 100 logarithmic scaled frequencies. They are presented in Figure below.

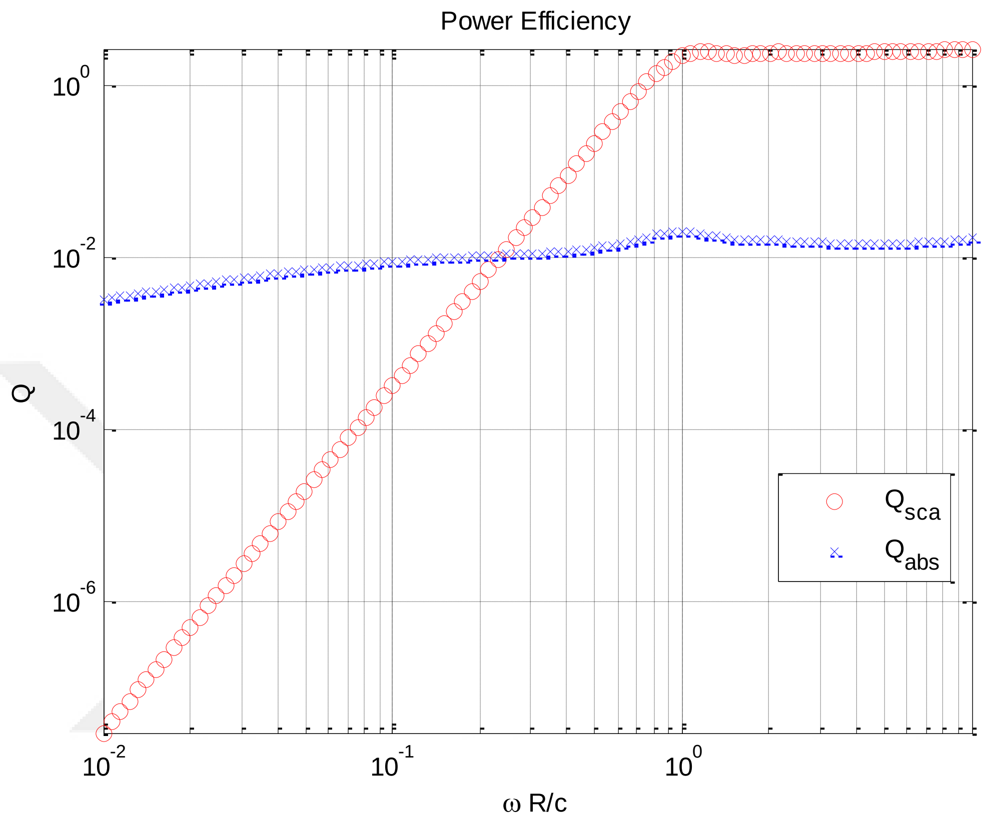

Figure 5.5. Effect on power efficiency.

5.3. SCATTERING FROM ANRSOTROPIC CYLINDER ABOVE PEC SURFACE

Case 1

In order to validate our proposed method, we firstly consider scattering from anisotropic inhomogeneous impedance circular cylinder with radius 1m located on free space is considered for TM incident case, since analytical solution based on serial expansion method is available. The incidence angle is chosen $\varphi_0 = 0^0$ .In this case, Green's function of free space medium which is only first terms of eq (18) is used. The parameterization of the boundary and anisotropic surface impedances are given respectively as $\partial D = \{r(t) = (\cos t, \sin t),\ t \in [0,2\pi)\}$ and $Z_{zz}(t) = 100(1 + i)\cos(t), Z_{zt}(t) = 50(1+2i)\sin(2t)\, Z_{tz}(t) = 50(2+i)\cos(2t), Z_{tt}(t) = 100(1 + i \sin t).\ t \in [0,2\pi)$. Since the incident field is TM wave, TM and TE scattered widths are called as σ_{VV} and σ_{HV} and depicted in fig (5.6) and fig (5.7) respectively. Obtained results are compared with those obtained by analytical method in [52]. As seen from Fig (5.6) and Fig (5.7), good agreements are observed.

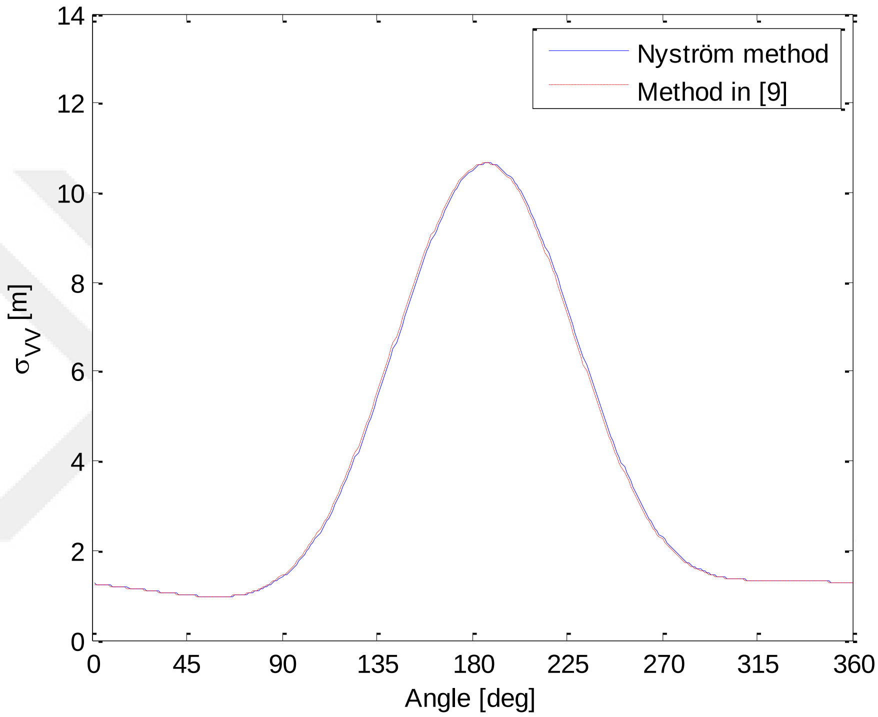

Fig 5.6. Scattering width σ_{VV} of the circular cylinder for case 1.

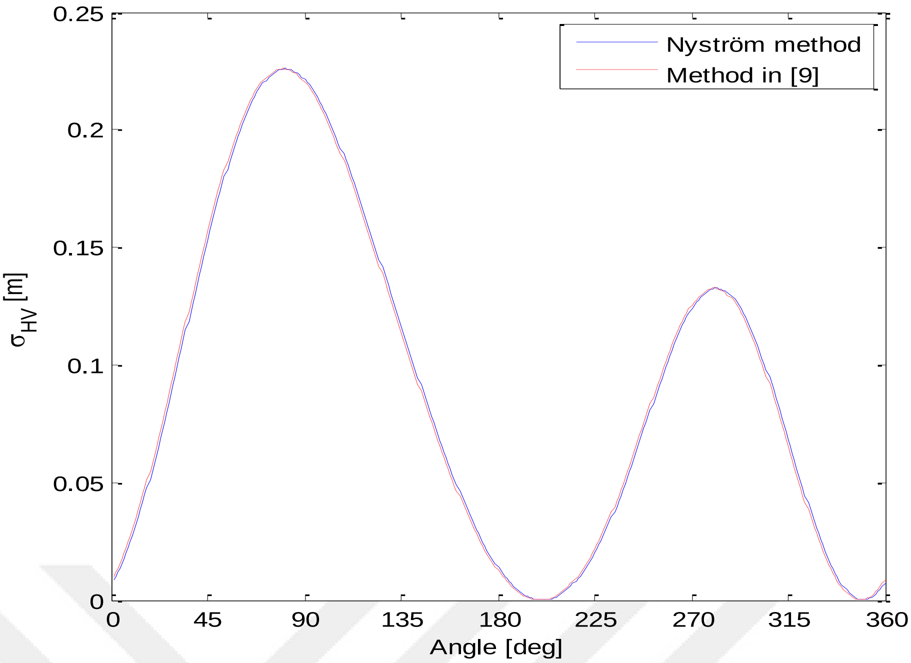

Fig 5.7. Scattering width σ_{HV} of the circular cylinder for case 1.

Case 2

Proposed method is applied for solution of scattering from anisotropic inhomogeneous impedance kite shaped cylinder above PEC plane for TM and TE incident cases. The incidence angle is chosen $\varphi_0 = 90^0$. The parametric representation of boundary and anisotropic surface impedances are given respectively as $\partial D = \{r(t) = (\cos t + 0.65\cos(2t) - 0.65,\ 1.5\sin t + 5),\ t \in [0,2\pi)\}$ and $Z_{zz}(t) = 10(1 + 6i)\cos(3t)$, $Z_{zt}(t) = 20 + 100i$, $Z_{tz}(t) = 50 + 60i$, $Z_{tt}(t) = 10(1 + 6i)\cos(3t)$, $t \in [0,2\pi)$. Polarimetric scattering widths $\sigma_{VV}, \sigma_{VH}, \sigma_{HV}$ and σ_{HH}based on definition (53) are obtained. $\sigma_{VV}$and σ_{HV} are depicted in fig (5.8). $\sigma_{VH}$and σ_{HH} are depicted in fig (5.9). Since we are only interested in fields above PEC plane that is for y>0 and all fields for y<0 is zero, these figures are plotted for angle range (0,180) that defines y>0 region.

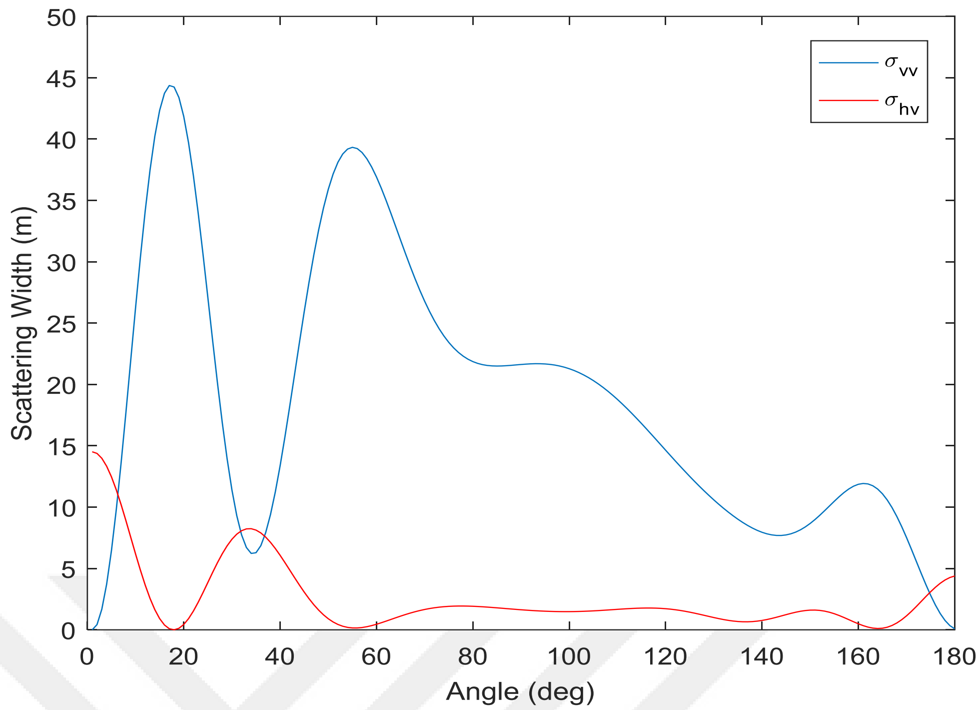

Fig 5.8. Polarimetric scattering widths σ_{VV} and σ_{HV} of the kite shaped object for case 2.

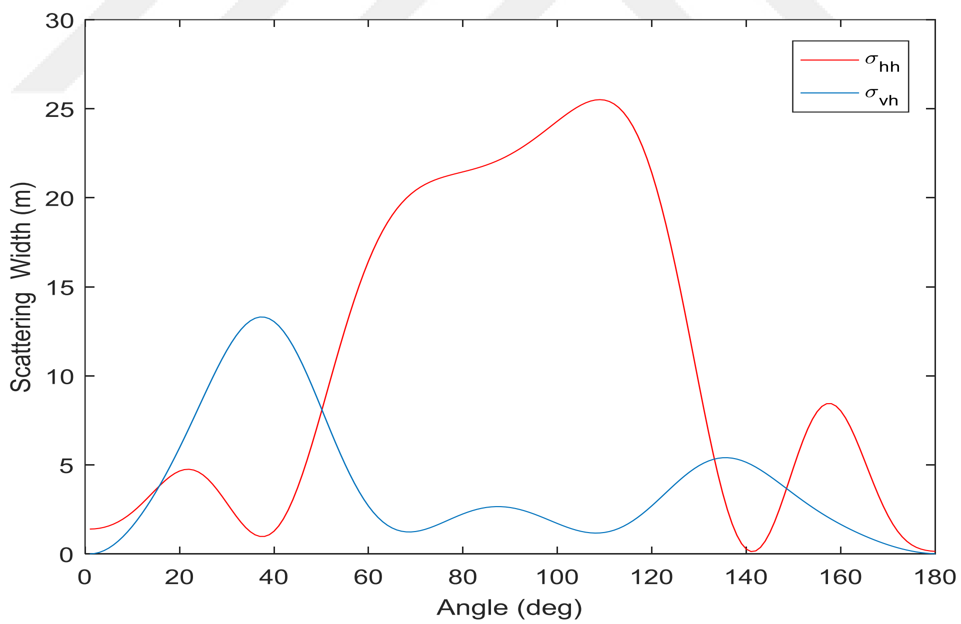

Fig 5.9. Polarimetric scattering widths σ_{VH} and σ_{HH} of the kite shaped object for case 2.

PART 6

CONCLUSION AND FUTURE WORK

In this work, the Mie Scattering strategy has been conducted to break down the EM dispersing qualities of self-assertively molded PEC targets covered with the electric anisotropic media. The utilization of the Mie Scattering strategy fundamentally diminishes the unpredictability of the calculation of the impedance grid just as the arrangement of the time. It many ways it may be presumed that this strategy is still extremely basic and productive in the development of the impedance grid components despite the fact that the dispersing target is exceptionally intricate with half of the PEC surface and anisotropic object placed in it.

Moreover, this technique can be effectively reached out to the investigation of the dispersing issue of PEC targets covered with multi-layered electric anisotropic media. In spite of the fact that this technique is basic and very effective in the calculation of the impedance lattice, the Mie Scattering strategy itself can't lessen the memory necessity likewise as the customary MoM in light of the fact that the impedance framework does not change its unique "full" trademark. In the creator's conclusion, it is smarter to join this strategy with other quick calculations, for example, the trademark premise work technique, to break down the electrically enormous articles.

We proposed to characterize 3D HOIBC, which was presented in [R-Sb], as far as decayed Hodge administrators (LD and LR). TE and TM polarizations help us to decay issue on two basic ones of every two-dimensional case, where we can without much of a stretch decide coefficients for 2D HOIBC and use them for 3D HOIBC as well. We have demonstrated the presence and uniqueness hypotheses, thus we set a few confinements on the coefficients. We proposed new 3D issue plan. We found that 3D plan experiences issues with administrators. What's more, we proposed two diverse approach to maintain a strategic distance from this trouble in discrete issue.

At long last, we introduced some 3D numerical outcomes for dissipating issue. In [R-Sb] it was talked about HOIBC that incorporates shape of a covering. In [BS] it was examined multi-layer covering cases. By and by the surfaces are inhomogeneous.

As innovation advances quickly in the region of computational electromagnetics, there is a lot of space for future investigations. The accompanying things speak to some conceivable future work headings.

1. The reenactment in this proposal was performed by utilizing a (PC), in which the figuring assets are restricted. The size of issue can be understood is compelled by the accessible figuring assets on the PC. By utilizing parallel registering, it is conceivable to join the figuring assets of a bunch of PCs to take care of bigger issues.

2. The essential capacities utilized in this proposal are of low request. Higher-request premise capacities empower the utilization of bigger patches for the discretization and henceforth lessen the complete number of questions. Likewise, the higher-request premise capacities are additionally ready to expand the exactness of the arrangement. By consolidating the higher-request premise capacities with the AIM, we expect that the effectiveness of the code can be expanded.

3. The investigations in this proposition are performed in recurrence space, which infers every reenactment will just create results at a specific recurrence. So as to play out the investigation over a wide scope of frequencies, we can depend on the time space examination. By embracing the time space AIM examination, we can play out a quick recurrence clear investigation for an enormous scale dissipate.

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