زانكۆی سەلاحەددین - هەولێر
Salahaddin University-Erbil

Design and Analysis of Dipole Antenna by using COMSOL Multiphysics Software

Research Project
Submitted to the Department of Physics in Partial Fulfillment
of the Requirements for the Degree of (B.Sc.) in Physics
(Communication Physics)

By:

Fatima Abdulsamad

Sana Burhan

Supervised by:

Dr. Hersh A. Khizir

Erbil- Kurdistan
April-2024

Statement

I hereby affirm that the (B.Sc. Research project) titled "**Design and Analysis of Dipole Antenna using COMSOL Multiphysics software**" represents my original work. I certify that all content within this research is the result of my independent research unless explicitly cited otherwise. Furthermore, I attest that this work has not been previously submitted for the award of any other degree at any institution, except where proper acknowledgment is provided.

Student names: ***Fatima Abdulsamad and Sana Burhan***

Signature:

Date:

Supervisor certificate

This research project has been composed under my supervision and is being submitted for the conferral of the degree of B.Sc. in Physics (Communication Physics), with my endorsement as supervisors.

Dr. Hersh A. Khizr

Signature:

Date:

Acknowledgment

I deeply grateful to **Allah** for His boundless grace and the successes, He has bestowed upon us throughout this journey.

I extend my heartfelt gratitude to my supervisors (**Dr. Herish A. Khizr**) whose valuable guidance and support have been instrumental in the successful completion of this study.

I am profoundly grateful to my **Family** and **Friends** for their unwavering support throughout this journey.

Abstract

In this study, the most basic kind of radio antenna is a dipole, which is made up of two copper wire rods that are half as long as the maximum wavelength the antenna can produce. It can be achieved by applying a sinusoidal voltage differential between two copper rods. This study presents a model that uses COMSOL Multiphysics to design an analytical solution for a dipole antenna. In the middle, between the two wires, dipole antennas receive radio frequency voltages.

List of Contents

List of figures

Chapter One

Introduction

Introduction

Dipole antennas are a class of single element antennas in the kind of wire antenna (John wiley et al, 2016), dipole Aerial is also called Dipole Antenna or Doublet (J. Lei and colleagues, 2006). A common definition of an antenna is a device that connects the guided wave and the free spaced wave. Basically, it's simple to design an antenna with an electric driver and is designed for radio frequencies. secondly the most widely used and basic antenna in all applications is the dipole antenna (John wiley et al, 2016). Antennas are required for all radio-frequency instruments. An antenna is usually made up of a number of metallic wires that are connected to the transmitter or receiver electrically. The antennas transform vibrations into electromagnetic waves that are free to go over space (Dhande, 2009). Since a dipole antenna is made up of two equal conducting elements, such as a rod or a metal wire, the name "dipole" refers to the "two poles" (Reddy, V.R.S. et al, 2023). At the operating frequency, the length of the metal wire in free space is about half of the wavelength. The most common kind of dipole antenna is the half wave dipole. As the name states, the total dipole antenna length at the operating frequency is equal to the half-wavelength (Reddy, V.R.S. et al,2023).

The objective of this article is to use COMSOL Multiphysics software to analyze and design a dipole antenna, represent the radiation pattern, and demonstrate how the variables change in relation to one another.

Literature review

Dipole antennas' efficiency, adaptability, and simplicity make them essential parts of wireless communication systems (Kuo, L.C. et al, 2007). Many studies have been conducted on the design and analysis of dipole antennas, and improvements in computational tools have made modeling and optimization methods more precise. The capacity of COMSOL Multiphysics software to model the electromagnetic behavior of intricate structures, such as dipole antennas, has made it an increasingly common option among these types of devices (Hamad, A.H. et al, 2019). Dipole antennas are a class of single element antennas in the kind of wire antenna, since a dipole antenna is made up of two equal conducting elements, such as a rod or a metal wire (John wiley et al, 2016). COMSOL Multiphysics software has been used in a number of studies to simulate the performance of dipole antennas at different frequencies and operating conditions. In these simulations, calculating the electric and magnetic fields surrounding the antenna structure frequently entails solving Maxwell's equations (Madsen, S.F. et al, 2011), Researchers can fine-tune the antenna's impedance matching, radiation pattern, and gain by modifying parameters like antenna dimensions, feed point location, and substrate material properties (John wiley et al, 2016).

Chapter Two
Software and Antenna Design Consideration

About software

Engineering and research now are heavily relying on computer simulation. Consistent user interface and experience are guaranteed for a variety of engineering and physics phenomena with COMSOL Multiphysics. The preferred program for finite element analysis, solver, and Multiphysics simulation is this one. It provides linked partial differential equation systems and standard physical user interfaces. COMSOL Multiphysics is enhanced by specially designed features for electromagnetic, structural mechanism, acoustics, fluid flow, heat transfer, and chemical problem solving. When starting new projects, using COMSOL makes it easier to understand the challenges, especially when designing easily useable miniatures.

The conversation that follows will offer perspective that advance your goals. It entails converting real world laws into virtual ones. A consistent user interface and experience across different engineering and physics phenomena are guaranteed by COMSOL Multiphysics. The conversation that follows will insights that support your goals.

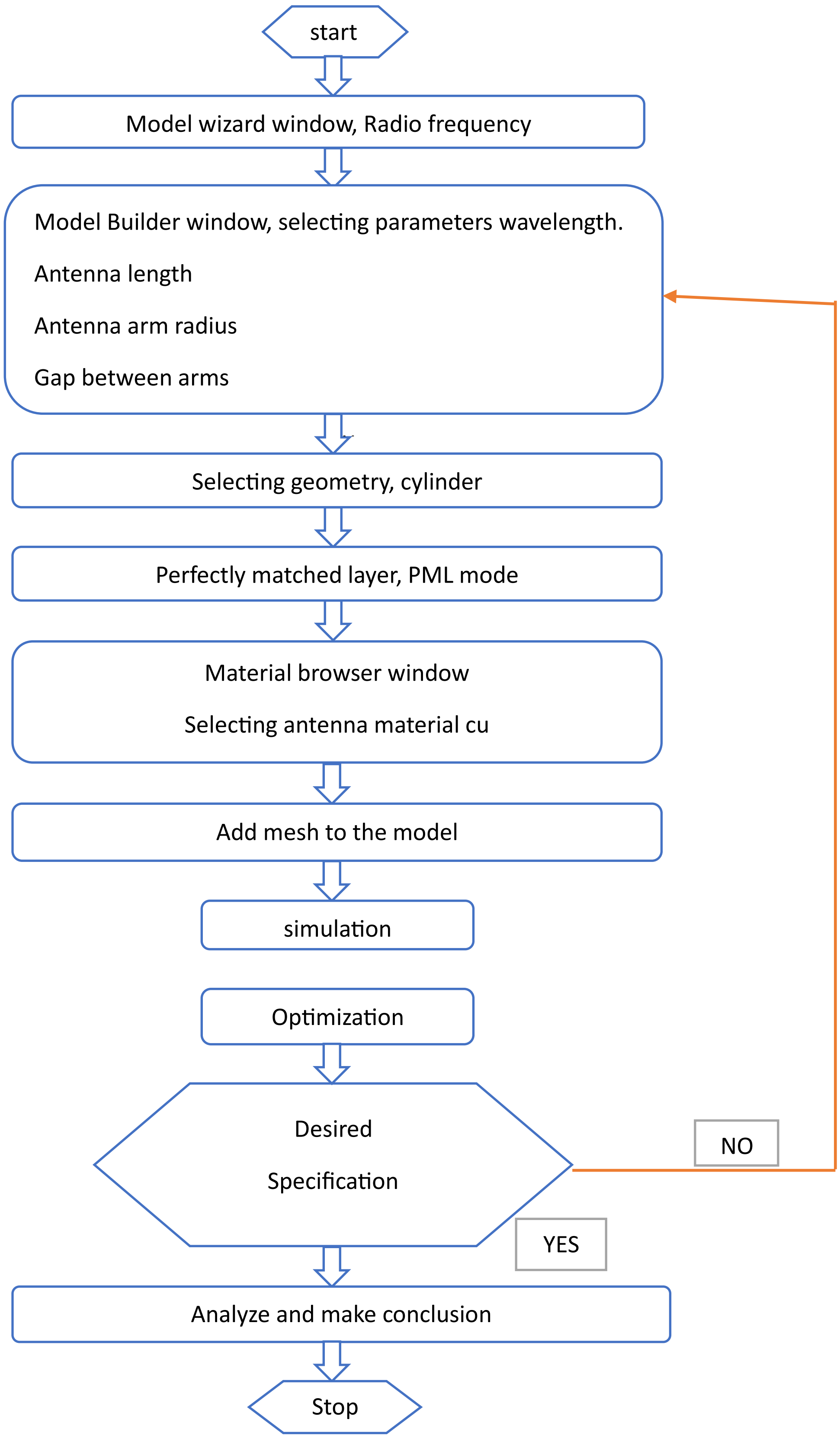

Figure 1 Simple dipole antenna.

Antenna design considerations

|Table (1). The following features are included in the antenna that we will design and are shown in the table below:

Name	**Expression**	**Value**
lda0	2[m]	2m
arm_ length	lda0/4	0.5m
r_ antenna	arm_ length/20	0.025m
gap_ size	arm_ length/100	0.005m

1. **lda0** operates the wavelength, i.e., the antenna wavelength.

2. **arm_ length** defines the length of arm of the dipole antenna to be developed.

3. **r_antenna** is the dipole antenna's arm radius.

4. **gap_size** provides information about the arms gap.

Chapter Three
Simulation Result and discussion

Simulation results and discussion

Fig (2) displays the Dipole antenna's proposed geometry. The radius of the antenna's 0.5 m long arms is 0.025 m. There is a 0.005-meter-long, slightly cylindrical gap between the two arms.

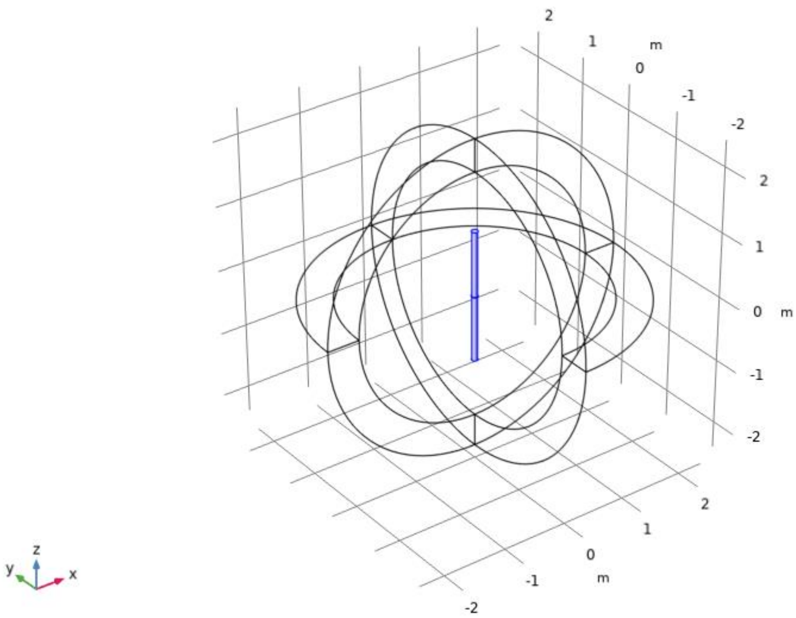

Figure 2 Dipole antenna geometry.

Fig (3) displays the magnitude of the electric field surrounding the antenna. Both at the ends of the arms and close to the excitation, the fields appear unexpectedly high. The fields at sharp transitions in the model are locally artificially high, but they have no effect on the results some distance (1~2 elements) away from these regions. These intensity peaks are caused by local singularities.

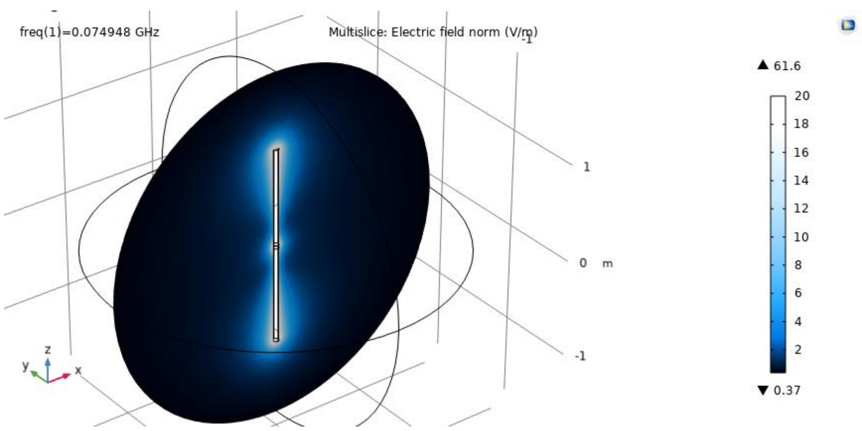

Figure 3 A slice map showing antenna's electric field magnitude**.**

displays a dipole antenna with mesh. The greatest element size is 0.5 mm, while the smallest is 0.09 mm. The maximum growth rate is 1.5, and the curvature factor is 0.6.

.

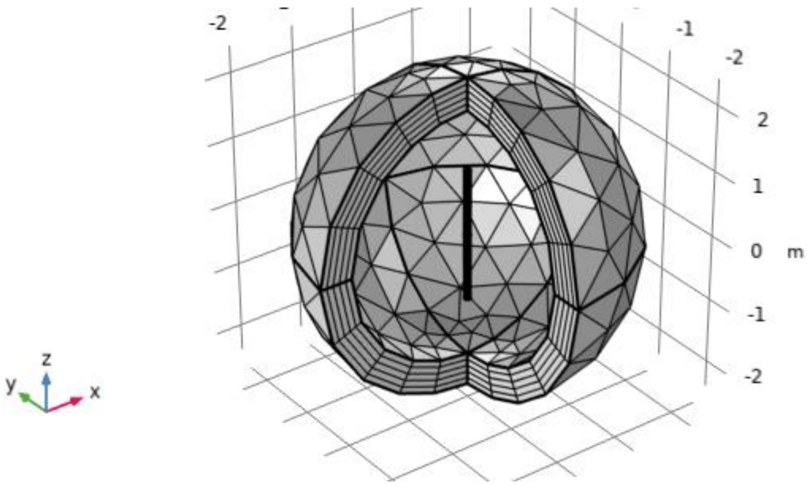

Figure 4 Antenna geometry with mesh.

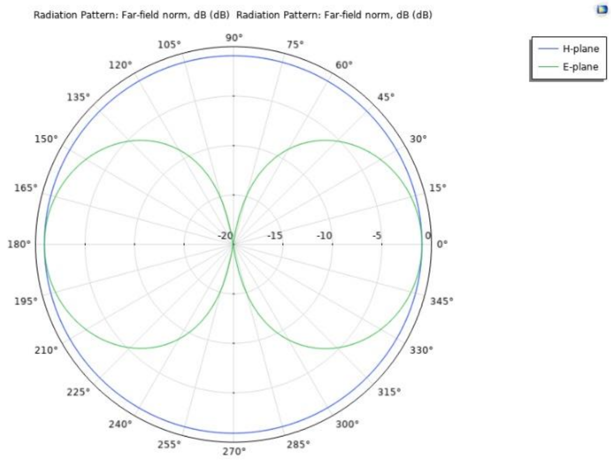

Figure 5 The isotropic polar plot of the distant field pattern in the xy-plane.

The projected H-plane pattern is omnidirectional (isotropic) on the xy-plane, as Fig (4) shows. The E- and H-planes of a linearly polarized antenna are defined by the antenna main polarization antenna. The E-plane contains the major polarization, or Ez in this model, while the H-plane is perpendicular to the main polarization.

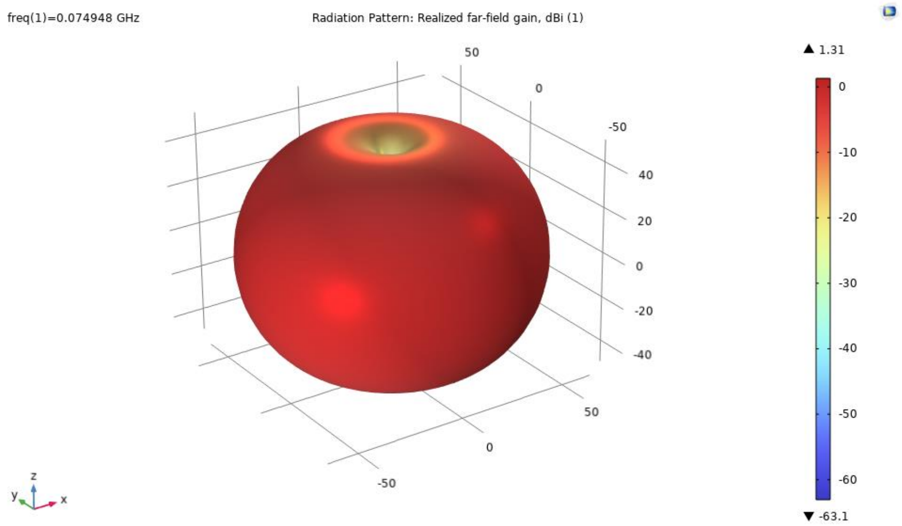

Figure 6 The predicted torus-shaped pattern may be seen in a 3D depiction of the dipole’s far-field pattern.

The features of the proposed antenna, following study, are as follows: The computed impedance for the port is 120.93 + 28.32i, which is consistent with predictions. The model approaches the analytic solution for dipole antennas when the antenna radius and gap height approach zero, as well as the mesh refinement limit.

Chapter Four
Conclusion and Reference

Conclusion

The analytical solution for a dipole antenna is presented in this work, and COMSOL Multiphysics will be used in its design. Both at the end of the arms and close to the execution, the fields appear unnaturally high. The predicted torus-shaped pattern was displayed in a three-dimensional plot of the dipole antenna's far-field pattern.

Reference

Balanis, C.A., 2016. Antenna theory: analysis and design. John wiley & sons. Antennas and its Applications. DRDO Science Spectrum, pp.66-78.

Dhande, P., 2009. Antennas and its Applications. DRDO Science Spectrum, pp.66-78.

Hamad, A.H. and Mian, A., 2019. Radio frequency response of flexible microstrip patch antennas under compressive and bending loads using multiphysics modeling approach. *International Journal of RF and Microwave Computer-Aided Engineering*, *29*(3), p.e21649.

J. Lei and colleagues, An omnidirectional printed dipole array antenna with curved radiation pattern in the elevation plane, Journal of Electromagnetic Waves and Applications, Vol. 20, No. 14, 1955–1966, 2006.

Kuo, L.C., Chuang, H.R., Kan, Y.C., Huang, T.C. and Ko, C.H., 2007. A study of planar printed dipole antennas for wireless communication applications. *Journal of Electromagnetic Waves and Applications*, *21*(5), pp.637-652.

Madsen, S.F., Mieritz, C.F. and dk ApS, H., 2011. Current distribution and magnetic fields in complex structures using Comsol Multiphysics. *Comsol. Com*.

Reddy, V.R.S., Sai, B.N., Kumar, N.V.P., Reddy, S.S.V. and Kathyayani, B.S., 2023. Design of dipole aerial by using COMSOL multi physics software. Materials Today: Proceedings, 80, pp.3481-3485.