

EMR assignment

by Owen Miller

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Electromagnetic radiation

ACDC5009

Owen Miller

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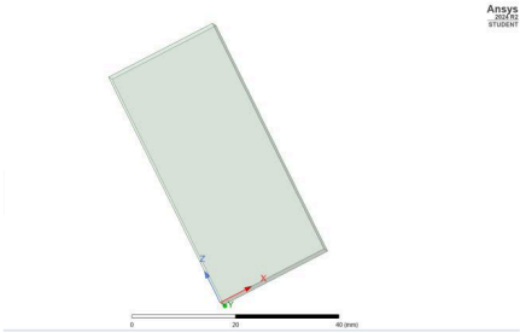
Task1

Abstract

The primary objective of this paper was to develop two waveguides utilizing high-frequency simulation software (HFSS). Subsequently, the findings obtained from the HFSS were analyzed and discussed. The first waveguide was designed using Perfect Electric Conductor (PEC) and was filled with a vacuum, while the second waveguide was also constructed from PEC but filled with Teflon. Both waveguides were engineered to have identical dimensions and were evaluated over the same frequency range of 2 GHz to 30 GHz.

Methodology

To determine the dimensions of the base waveguide, I calculated both the height and width. Using the number 2307075, the first two digits represented the height in millimeters, which was set at 23 mm. The width was calculated using the third and fourth digits, divided by 2 and rounded to the nearest whole number. This led to a calculated width of 4, as $(0 + \frac{7}{2} = 3.5)$. The z-axis measurement was pre-approved at 50 mm.

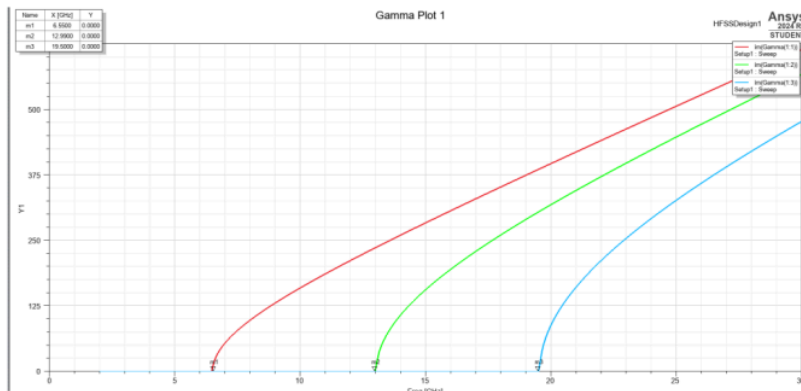


Ansys
HFSS
STUDENT

Next, I loaded HFSS to construct the waveguides. Initially, I created a simple box with the appropriate dimensions. After constructing the box, I selected the material; for both waveguides, I chose Perfect Electric Conductor (PEC). Additionally, the interior of the box needed to be filled with a material. To investigate the differences in performance, I selected a vacuum for the task 1a waveguide and Teflon for the task 1b waveguide. This choice was made to observe how the different waveguides would respond to the frequency sweep.

Once the materials were selected, I added excitation ports to the waveguide, which is where the RF signal would be introduced. The excitation points were located at either end of the waveguide (see Fig. 2). It was crucial to position these ends correctly, as this would allow the wave to propagate

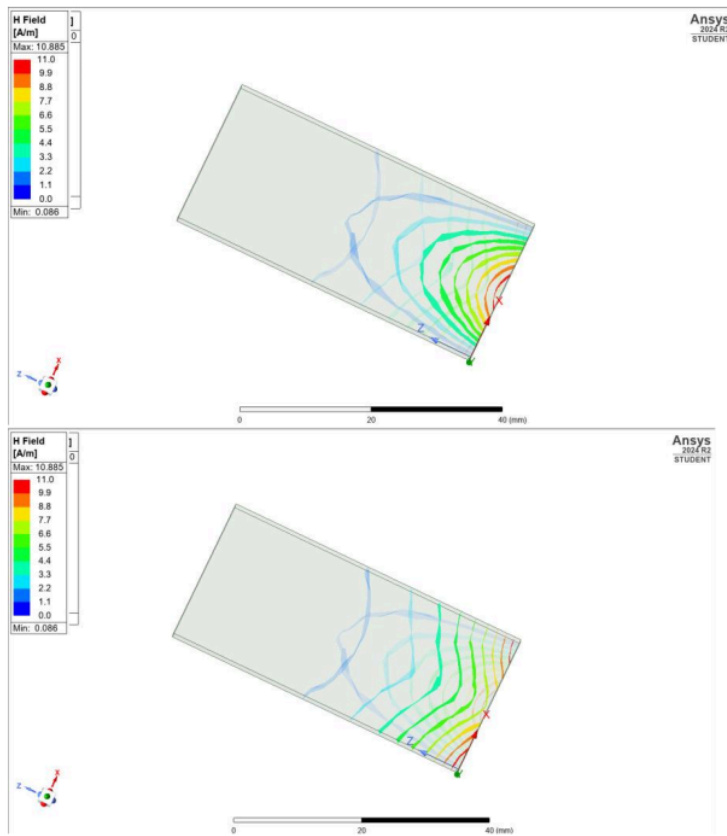
effectively through the waveguide. Since electromagnetic waves are self-propagating, this alignment was important for accurate results.



The graph illustrates the optimal frequency ranges for wave transmission within a waveguide. Specifically, it indicates that any wave frequency exceeding 20 GHz or falling below approximately 6 GHz is not suitable for effective transmission. When waves outside of this range are used, they may experience unwanted modulation and reflections as they travel through the waveguide. This reflection causes the waves to return through the same port from which they were initially transmitted, introducing noise and interference into the signal. Such interference can not only degrade the quality of communication but may also result in signal leakage, which can pose safety risks in certain applications.

Following this analysis, the next test conducted focused on the radiation field generated by the transmitted waves within the waveguide. This test provides insights into the trajectory and behavior of the waves as they traverse the guide. To thoroughly analyze this phenomenon, two distinct examples were considered: one depicting the electric field and the other illustrating the magnetic field. The inclusion of both examples is crucial because electric waves propagate perpendicularly to the magnetic field encasing them.

In an ideal waveguide designed for the Transverse Electric (TE) mode, the propagation of the wave occurs along the length of the guide, while the associated magnetic field wraps around it in a specific pattern. This configuration enhances the efficiency of the wave transmission, minimizing losses and maximizing signal integrity. For a visual representation of this behavior, please refer to Figures 4 and 5, which showcase the results of the radiation simulation.



The detailed analysis of the two figures reveals that the waveguide is experiencing considerable reflection, which ultimately leads to a notable decrease in efficiency. This is clearly represented by the thin dark blue line situated at the top of both figures, effectively illustrating the extent of reflection occurring within the waveguide structure. The simulation results strongly indicate that the current configuration of the waveguide is suboptimal for achieving effective wave transmission.

To enhance its performance, it is crucial to modify several key parameters of the waveguide. This may involve adjusting aspects such as its physical dimensions, the materials used in its construction, or its alignment with respect to the input wave. By implementing these optimizations, we can expect a significant reduction in reflection, which should, in turn, lead to a marked improvement in overall transmission efficiency.

Task2

Introduction

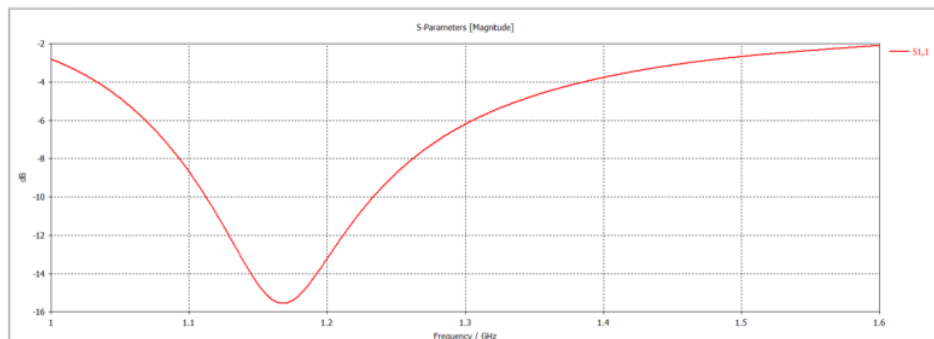
This report presents the design and testing of a dipole antenna, with a focus on the specifications that guided its development. The excitation point for the antenna was strategically placed in the middle. The following sections will detail the methodology employed to create and analyze the dipole antenna using high-frequency simulation software. Additionally, the report will include visual representations and examples that demonstrate the antenna's operational characteristics, including its radiation field and frequency response.

Methodology

A dipole antenna is composed of two radiating elements with a central radiating surface. To achieve optimal performance, the length of the dipole should be tailored to half of the wavelength corresponding to the desired operational frequency.

Initial calculations were conducted to determine the length of the electromagnetic waves to be radiated. These calculations were based on data provided in 2307075. With a wavelength of 230 mm, the design of the ideal dipole antenna is to be half of this length, resulting in an impedance of 50 ohms. This impedance strikes an effective balance between minimizing signal loss and ensuring adequate power handling capacity. Consequently, the calculation for half of the wavelength is straightforward: 230 mm divided by 2 yields 115 mm.

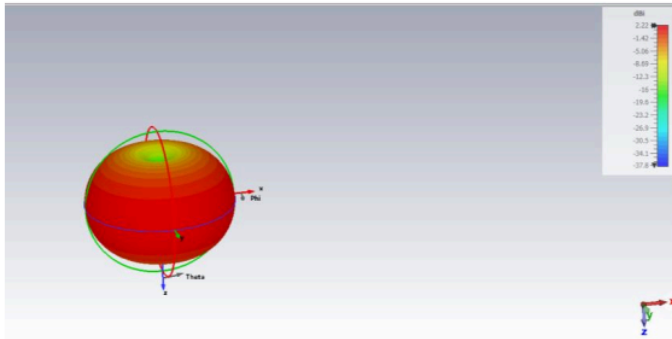
Figure 10 below illustrates an example of the dipole antenna featuring the excitation surface at its center. The model was created in High-Frequency Structure Simulator (HFSS) using two cylindrical elements and a radiating surface. The antenna was constructed from Perfect Electric Conductor (PEC) material, which radiates effectively into a vacuum.



The antenna is currently functioning at a frequency that falls approximately 1.125 GHz below the desired target frequency of 1.3 GHz. To rectify this difference, it will be essential to make adjustments to the antenna's design, specifically by modifying either its width or length. The original design established the dipole length as half of a 230 mm wavelength, providing a solid foundation for these necessary changes.

Accompanying this analysis is a detailed 3D far-field diagram that vividly showcases the antenna's transmission capabilities. This diagram reveals the antenna's ability to provide efficient and uniform signal coverage in all directions surrounding the dipole. Areas marked in red on the diagram indicate zones of heightened intensity and efficiency in the emitted electromagnetic field, signifying strong

transmission performance in those regions. Overall, this visual representation not only highlights the antenna's technical specifications but also underscores its remarkable effectiveness in delivering a clear and powerful signal across a broad area.



Discussion

The antenna operates with impressive efficiency and generates a uniform far-field pattern, which is ideal for optimal signal transmission. However, upon careful examination of the calculations presented in the report, it becomes clear that the dipole antenna is not functioning at the specified frequency of 1.3 GHz. To address this discrepancy and improve performance, it is essential to modify the length of the dipole element. This adjustment requires a precise recalculation based on the desired frequency to ensure that the antenna achieves its full potential in terms of efficiency and effectiveness.

Conclusion

In summary, the specifications for the dipole antenna given in the brief need to be revised to reflect the necessary changes for frequency operation. Alternatively, a comprehensive revision of the brief itself may be necessary to outline the steps needed to correct the issues with the dipole's frequency transmission. Fortunately, the current design is quite close to the target frequency, indicating that significant alterations are not required. It is also important to emphasize that transitioning from simulation results to practical applications involves taking into account various real-world factors, including environmental conditions and physical limitations. These considerations are essential to ensure the final design is both effective and reliable in actual operating environments.

Task3

Radar systems are sophisticated technologies primarily designed for the detection and tracking of airborne objects, including drones and commercial airplanes. These systems emit radio waves from a transmitter, allowing for the precise monitoring of aerial traffic. The radio waves travel through the atmosphere and, upon encountering an object—whether it be a small drone or a large aircraft—reflect back toward the radar system. This interaction generates an echo that can be analysed to extract critical information about the object.

The radar system's receiver accurately measures the time delay between the transmission of a radio wave and the subsequent return of the echo. By calculating this time delay, the system determines the distance between the radar unit and the detected aircraft with high precision. This information is crucial for effective air traffic management, as it enables air traffic controllers to monitor the

positions and movements of multiple aircraft in real-time, ensuring safe separation and efficient routing within controlled airspace.

In addition to distance measurement, advanced radar systems possess the capability to analyse the frequency, amplitude, and phase of the returning waves in detail. By evaluating these characteristics, radar technology can provide vital insights concerning the size, speed, and trajectory of the aircraft. For example, the Doppler effect allows for the determination of an object's speed through changes in frequency, while variations in signal strength can indicate its size.

The advanced capabilities of radar technology have made it an indispensable asset across a wide range of sectors. In air traffic control, radar systems are crucial for maintaining safe distances between aircraft by providing real-time tracking data. This allows air traffic controllers to manage flight paths effectively, preventing potential collisions and ensuring a smooth flow of air traffic.

In military operations, radar plays a pivotal role in threat detection by identifying and tracking enemy movements, missile launches, and other potential hazards in the vicinity. This capability enhances situational awareness and allows for timely responses to threats, ultimately contributing to mission success and the safety of personnel.

Additionally, radar technology is increasingly used in drone surveillance applications, where it helps monitor unauthorized activities, such as illegal border crossings or poaching. By providing detailed images and data about the movements of people or vehicles, radar aids law enforcement and environmental protection agencies in their efforts to maintain security and preserve natural resources.

Overall, radar technology facilitates the safe navigation of airspace and contributes significantly to the efficient management of aerial activities. Its role in enhancing security measures and operational effectiveness in the skies is vital, ensuring the safety of passengers, air traffic personnel, and critical infrastructure..

To enhance the capabilities of raiders in effectively tracking drones, a promising approach involves conducting thorough experiments to identify the optimal radar frequency tailored to the specific materials utilized in the construction of drone crowns. This process will require an in-depth analysis of the electromagnetic properties of these materials, including their reflectivity, signal absorption, and resonance characteristics.

By accurately determining the unique features that influence radar responsiveness, we can establish which frequencies will generate the most robust and clear signals. This methodical and targeted approach is expected to significantly improve radar efficiency, enabling more effective detection and tracking of drones across various environments, ranging from urban settings to open fields.

The implementation of these advanced methodologies will equip raiders with the tools necessary to better locate and address unauthorized drone activities, thus enhancing security measures and improving overall airspace management. This initiative represents a critical advancement in counter-drone strategies and supports our continued efforts to mitigate emerging aerial threats.

EMR assignment

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

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GRADING FORM: EMR MAY

OWEN MILLER

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ENGAGEMENT WITH LITERATURE

The report should demonstrate the use of relevant, high-quality academic and professional sources. Comprehensive research incorporating recent journal articles, textbooks, and reliable sources should be evident. The credibility of each source should be evaluated, favouring peer-reviewed materials. All references must follow IEEE format, with consistent in-text citations.



No evidence of reading or reliance on appropriate sources

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KNOWLEDGE AND UNDERSTANDING

The report must exhibit sound knowledge of RF principles, waveguides, and antenna theories. Theoretical concepts such as wave modes and propagation should be clearly explained. Concepts should be related meaningfully to practical contexts. The report should demonstrate how this knowledge informed the design decisions.



Knowledge is reasonably detailed and accurate, showing a good critical understanding of well-established concepts and principles related to antennas and waveguides. It demonstrates a basic understanding of TE modes, cutoff frequencies, antenna theory, radiation patterns, and provides a basic explanation of radar cross-section and UAV detection challenges. However, the waveguide and antenna analysis lacks depth. A deeper explanation of why a higher dielectric constant lowers the cutoff frequency would strengthen the analysis.

12.5

COGNITIVE AND INTELLECTUAL

The report should present a critical analysis of simulation results and theoretical data. Findings must be discussed with evidence, leading to logical and valid conclusions. Comparisons between theoretical and simulation results should be presented. Discussions should include implications, limitations, and alternative solutions.



Limited attempt at critical evaluation and analysis of concepts and principles of Electromagnetic Radiation, tending towards description. The report lacks comparative analysis between theoretical and simulated results. There is no use of tables or structured comparisons to show how the results align with theory. Many statements are presented as opinion without supporting technical evidence.

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PRACTICAL SKILLS

Appropriate engineering software and methodologies should be applied to design waveguides and antennas. The simulation process and parameters should be documented clearly, with justifications for methods used. Results should be presented with neat plots and visuals. Problem-solving skills should be demonstrated through analysis and design refinements.



A good and appropriate application of established methods, materials, tools and/or techniques. Clear appreciation of the context of the application. Mainly consistent, accurate and logical application of theory to practice, making appropriate links between the two. Can identify problems and propose mostly

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appropriate solutions outside the context in which they were first studied.

TRANSFERABLE SKILLS FOR LIFE

The report should be clear and well-structured for technical and non-technical readers. Complex ideas must be communicated effectively, with appropriate terminology and visual aids. A logical flow from introduction to conclusion should be maintained. Professional presentation elements such as clear headings, subheadings, and a well-organised reference list should be included.



Can communicate effectively in a suitable medium for the audience, but may have minor errors. The report is mostly well-organised, it would have been better with an introduction section at the beginning. Maintain a consistent technical tone. However, it would be improved by better alignment, appropriate caption for the figure, figure referencing in the description. A full proofread is recommended to enhance clarity.

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