

ACDC5009 - Student 2204725

by Gabriel Pan

Submission date: 12-Apr-2025 01:37PM (UTC+0100)

Submission ID: 255569618

File name: 52080_Gabriel_Pan_ACDC5009_-_Student_2204725_655802_342011401.docx (3.86M)

Word count: 4723

Character count: 25461

**B.Eng. (Hons) in Embedded Electronic Systems –
Electromagnetic Radiation – ACDC5009 – Design and
Analysis of Electromagnetic Systems**



Student ID: 2204725

Word Count: 4723

Contents:

Title.....	1
Contents.....	2

Part 1: 3-21

Abstract.....	3
Introduction.....	4-6
Methodology.....	7-8
Results.....	9-16
Discussion.....	17-19
Conclusion.....	20
References.....	21

Part 2: 22-32

Introduction.....	22
Literature Review.....	23-25
Social and Environmental Impacts.....	26-27
Discussion.....	28-30
Conclusion.....	31
References.....	32

Abstract:

This study was to explore the results of simulating a waveguide made out of PEC (Perfect Electrical Conductor) with a fill of vacuum then with Teflon and with a dipole made out of PEC again in a medium of vacuum. The eventual results were found, were accurate and as expected with the specified characteristics of the systems.

Introduction:



This study essentially is the study of 2 different wave guides and a di-pole antenna covering the propagating waves and all of the relevant data collated from simulating these in a simulation software. This will be backed up the physics underpinning the eventual results.

A rectangular waveguide is a hollow metallic structure designed to guide electromagnetic waves, typically in the microwave and millimeter-wave frequency ranges. The waveguide has a rectangular cross-section and supports various modes of wave propagation, with the dominant mode being the TE₁₀ mode. The dimensions of the waveguide are crucial in determining the cutoff frequency, below which wave propagation is not possible. Rectangular waveguides are commonly used in applications such as radar, satellite communications, and high-frequency transmission lines due to their low loss and high-power handling capacity.

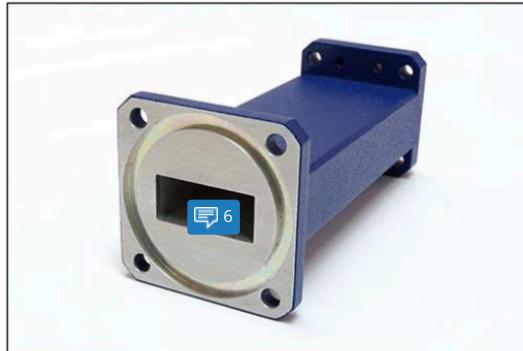


The operation of a rectangular waveguide can be understood in terms of the wave equation and boundary conditions. For a wave to propagate through the waveguide, it must satisfy the boundary conditions at the walls of the waveguide, which are typically metal. The cutoff frequency for a specific mode is determined by the waveguide's dimensions, and below this frequency, the wave will be evanescent, meaning it will not propagate.



Rectangular waveguides offer several advantages, including low attenuation and the ability to handle high power levels without significant losses. However, their use is limited by the relatively large size compared to coaxial cables, and they are generally more expensive and difficult to manufacture for lower frequencies. [3]

The first task was to create a wave guide, using randomized numbers as the dimensions of said waveguide, in the provided simulation software then gather the relevant data surrounding the propagated wave and the functions of the waveguide such as the E and H parameters in the waveguide and the dominant modes. The first waveguide is specified to have a medium of a vacuum, the second with a medium of Teflon and in both cases the waveguide itself is to be made of PEC (Perfect Electrical Conductor).



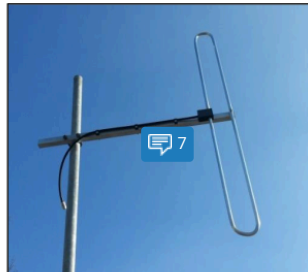
A half-wave dipole antenna is a type of resonant antenna that is commonly used in radio frequency (RF) communication systems. It consists of two conductive elements that are typically straight and collinear, with the total length of the antenna being approximately half the wavelength of the frequency it is designed to transmit or receive. The half-wave dipole is one of the simplest and most widely used antenna designs, due to its simplicity, efficiency, and predictable radiation pattern.

When excited at its resonant frequency, the half-wave dipole antenna exhibits a current distribution that has a maximum at the center and decreases towards the ends of the antenna. This configuration leads to a radiation pattern that is largely omnidirectional in the plane perpendicular to the axis of the antenna. The half-wave dipole antenna operates most efficiently when the length of each arm is approximately $\lambda/4$, where λ is the wavelength of the operating frequency. [4]

The main characteristics of a half-wave dipole antenna include a resonant frequency, defined by the relationship between the antenna's total length and the wavelength of the signal, and a relatively high radiation resistance around 73 ohms, making it a good match for typical RF transmission lines like coaxial cables. [5]

The half-wave dipole is often used as a reference antenna in theoretical and practical antenna analysis. However, it has limitations, such as a relatively narrow bandwidth and the requirement for a specific resonant length. These constraints can be addressed with variations like the multiband dipole or the inverted-V dipole, which modify the structure to broaden frequency ranges or improve performance in specific scenarios. [6]

The second task was to create a halfwave dipole antenna in the same software, again with randomized dimensions, and find the operating frequency by plotting the S-parameter graph in different frequencies and show the subsequent radiation pattern this is to be made out of PEC once again and surrounded by a vacuum.



Methodology:

For the first of two wave guides, the simulation was made by firstly making a rectangle shape with the randomized dimensions which for this was the writers student ID consisting in this case with the first 4 digits of '2204'. It was specified in the brief that 'a', the longer of the 2 dimensions in the x-y plane, is to be the first and second numbers of the student ID then 'b', the shorter, is to be the third and fourth numbers divided by 2. Both of these dimensions would be in mm. This results in the 'a' measurement of 22mm and the 'b' measurement of 2mm and, as specified in the brief the length of the waveguide would be 50mm. This results in a very narrow waveguide, which led to interesting results. Then, because the medium default in the simulation software the medium inside the shape was left unchanged and the material of the walls was set to PEC. The ports then had to be specified at the end of the waveguide in the x-y plane as this would be the plane the propagated wave would be travelling through. Again, as said in the brief, the ports were set with 3 modes. Then it was appropriate to set the testing parameter which would be a frequency sweep between 2 to 30GHz with a small enough step to be able to show all the data between these frequencies. This construction was then simulated in the software to collate the data and gain access to the results of the design.

Then, instead of starting a new project in the simulation software, the last project was simply modified with the space inside of the waveguide to be made out of teflon then re-animated with this adjustment then the results were collected again.

For the last task, which is to simulate a dipole antenna, the task was started by making a new project with a cylinder shape with randomized dimension using the same numbers from the student ID as before (2204). This consisted with the measurement 'a', denoting the total length of the antenna, which in this case was the first 2 digits which would be 22mm and measurement 'b' which denotes the diameter of the cylinder which is the third and fourth digit divided by 2 which would be 2mm. The final dimension specified was represented by the symbol λ is equal to the first 3 digits which is 220mm, this denotes the eventual wavelength of the propagated wave. The cylinder which was drawn in the software was then split in two at the origin of the x-y plane with a gap of 1mm to fit a wave port to set the origin of the wave to be propagated from, this was done by drawing a two-dimensional rectangle in either the y-z plane or the x-z plane to set as the wave port. The testing parameters were then set as a frequency sweep surrounding the desired frequency. This construction was then simulated in the software to collate the data and gain access to the results of the design.

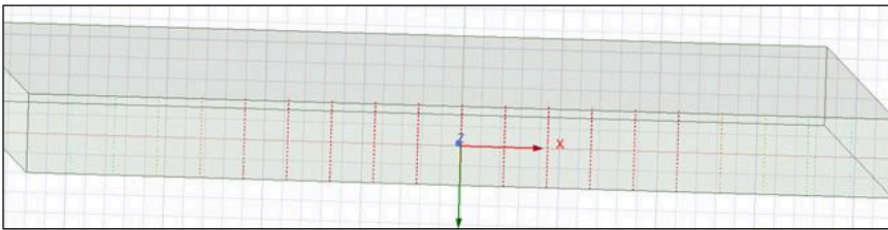
Results:

The following results were found by simulating the described designs in the simulation software. The following screenshots are the stated results required by the brief for this report.

9

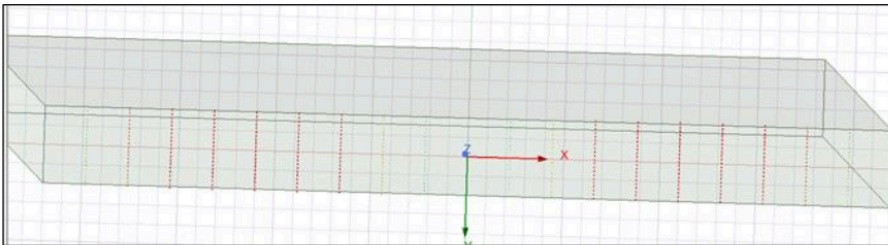
Wave Modes of Waveguide:

Mode 1 –

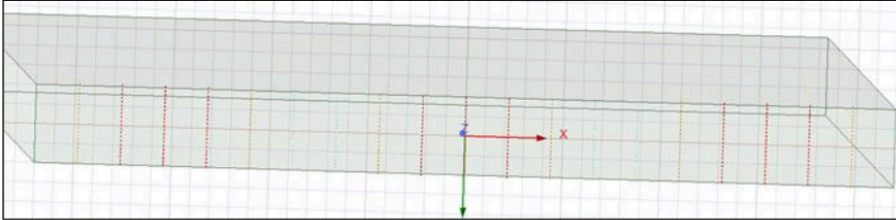


Mode 2 –

10

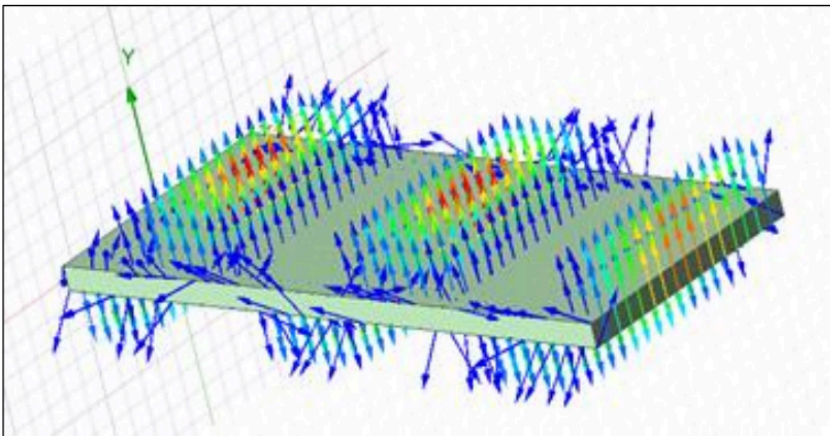


Mode 3 –

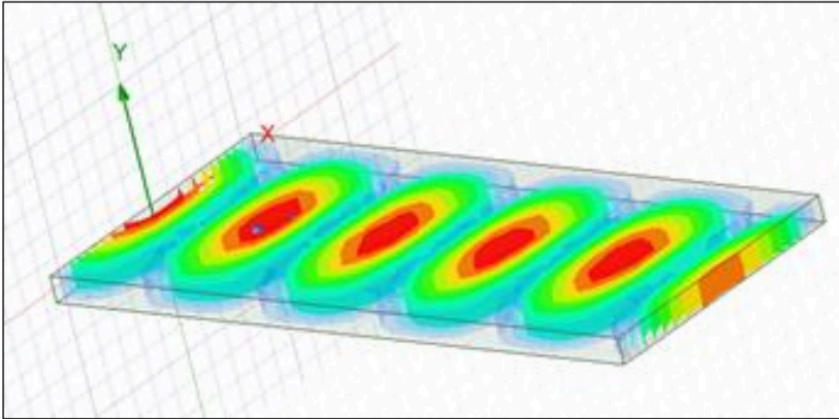


Task 1a. Vacuum Filled Rectangular Waveguide:

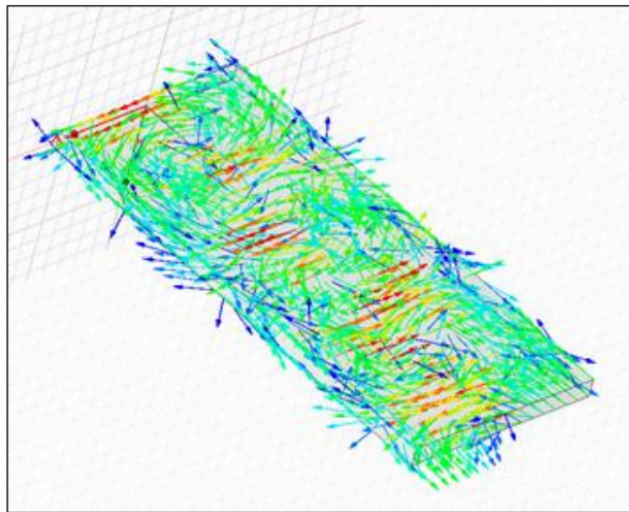
Vector E-Field –



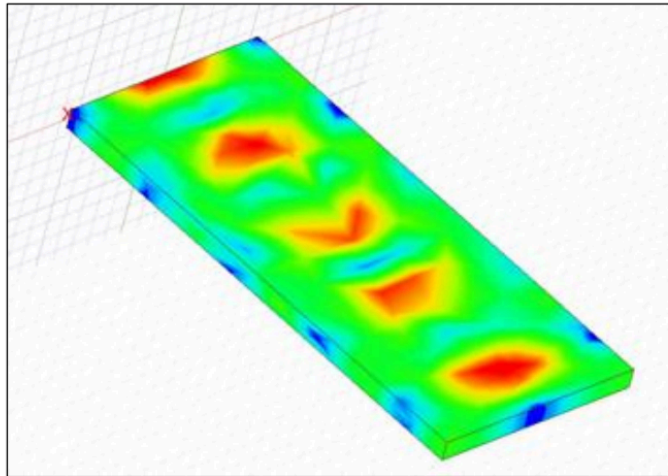
Magnitude E-Field -



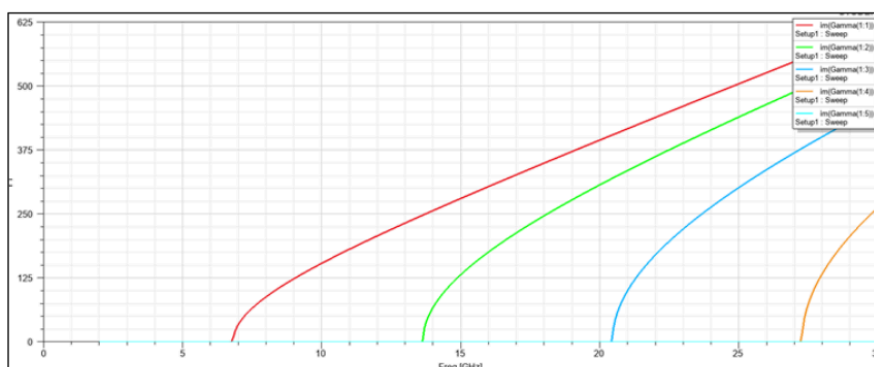
Vector H-Field -



Magnitude H-Field –

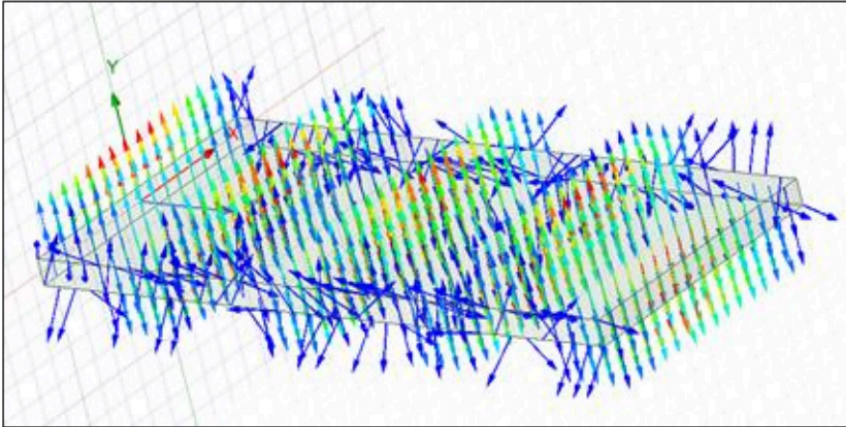


Cut-Off Frequency Graph –

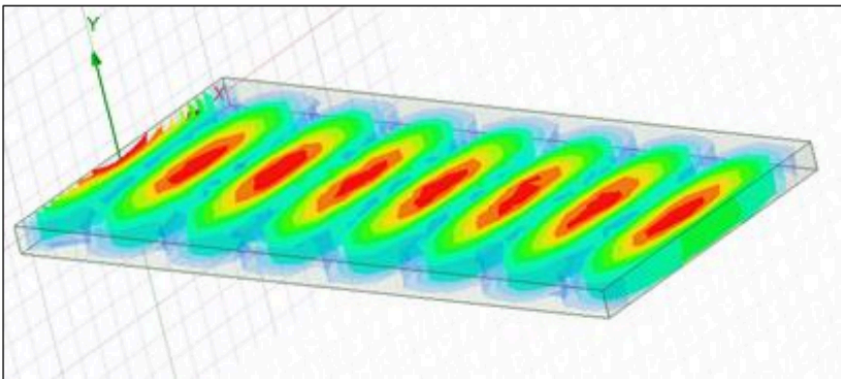


Task 1b. Teflon Filled Rectangular Waveguide:

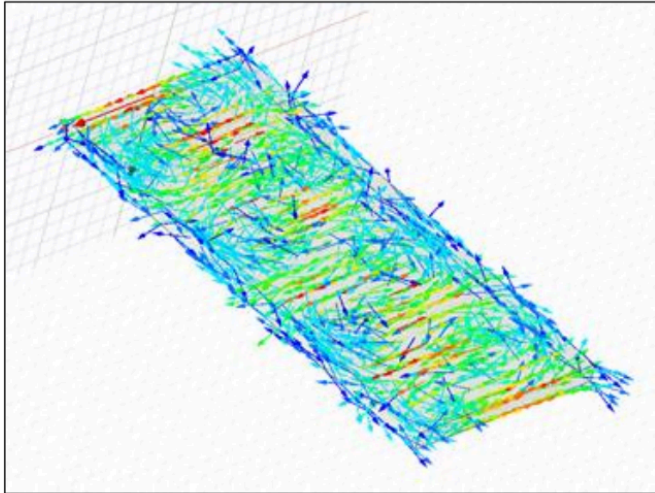
Vector E-Field –



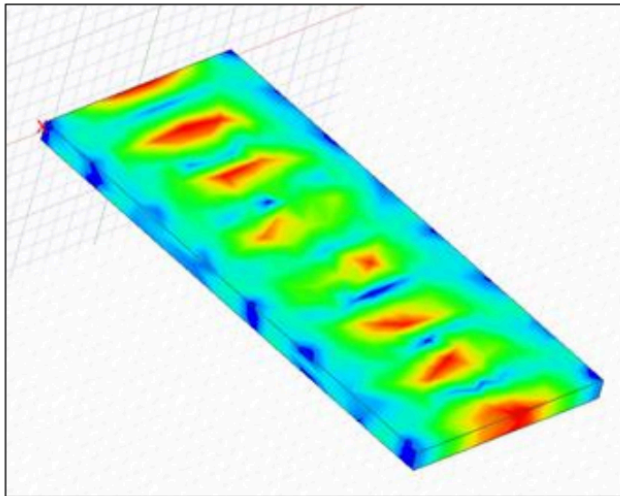
Magnitude E-Field –



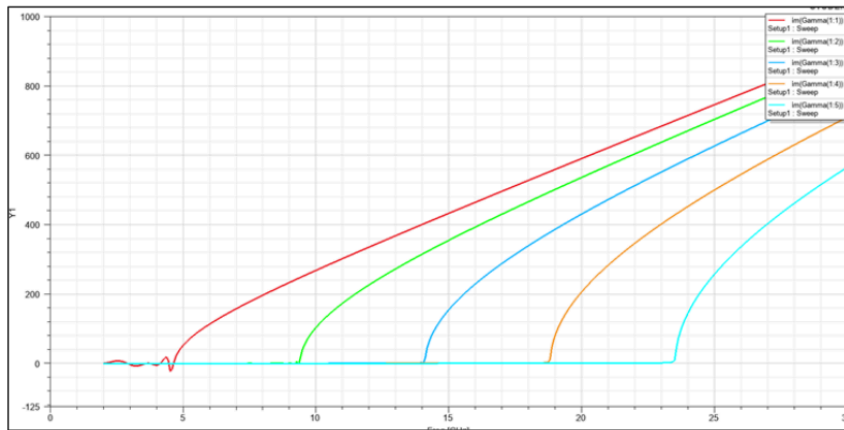
Vector H-Field –



Magnitude H-Field –



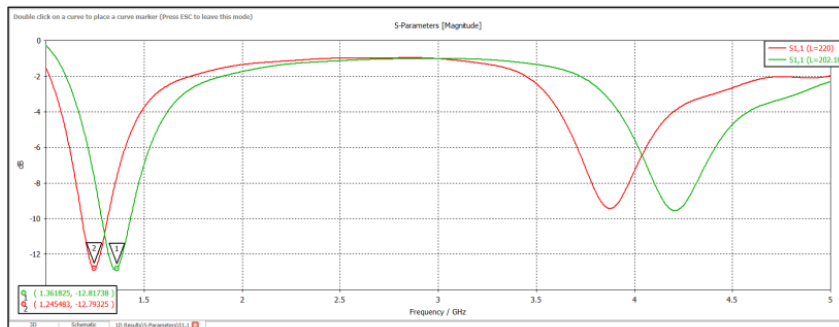
Cut-Off Frequency Graph –



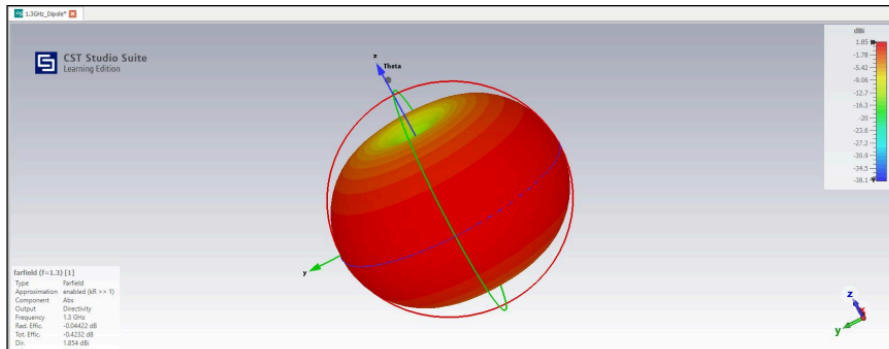
16

Task 2. Halfwave Dipole:

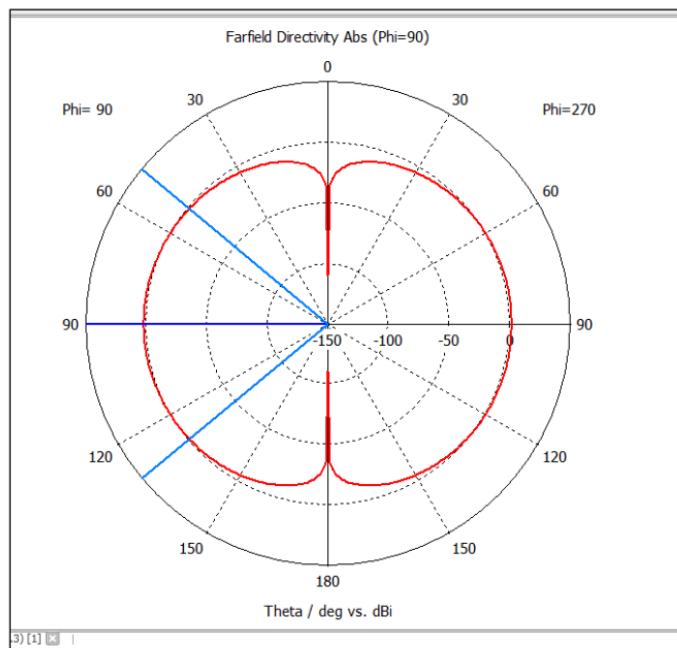
S-Parameter Graph –



Gain 3D Polar Graph –



Farfield directivity -



Discussion:

Task 1 Analysis: This section will cover the comparison of Teflon or a vacuum as a medium for the wave to propagate in.

The main difference noted was the difference in magnitude of the propagated wave in the wave guide, seen in the E and H field vector and magnitude visuals. This could be because of a lot of reasons:

1. Dielectric Constant and Propagation speed

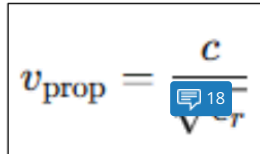
The dielectric constant, also referred to as the relative permittivity, of a material affects the speed of the EM (Electro-Magnetic) wave propagation within a waveguide. In a vacuum the relative permeability is exactly 1, whereas Teflon has a value of around 2.1. The equation for the velocity of wave propagation is as follows:

This is where:

v_{prop} = The velocity of the wave propagating

c = The speed of light (3×10^8 m/s)

ϵ_r = The relative permeability of the material in the waveguide


$$v_{prop} = \frac{c}{\sqrt{\epsilon_r}}$$

As you can see the relative permeability of the material the wave is propagating through is inversely proportional to the resultant propagation speed. Therefore, Teflon, with a relative permeability of 2.1 would be slower than the wave being propagated in the vacuum, this could explain the differences in the E and H field strengths.

2. Power Handling and Breakdown Strength:

The breakdown strength of a material defines the maximum electric field it can withstand before it starts dielectric breakdown and becomes a conductive material. This means that this is very important for higher power applications. A vacuum has an extremely high breakdown strength due to there being no material in the medium to ionise, this means that a vacuum is an ideal choice for higher-power transmissions without the risk of breakdown. Whereas Teflon has a limited dielectric breakdown strength, typically in the range of 60MV/m, but still a very high capacity. However, due to this there is a limitation at higher powers in Teflon that is otherwise not present in a vacuum; this could also explain the discrepancy in the results between a vacuum and a Teflon medium.

3. Frequency Dependence:

The frequency dependence of a propagating wave and its losses is an important component in selecting materials for waveguides. In a vacuum there are no material properties that change with frequency, this means that it performs the exact same over all frequencies. However, in Teflon the dielectric constant and loss tangent are frequency dependent; in lower frequencies, like RF and microwave bands, Teflon proves to be efficient but in very high frequencies (above a few GHz) there are losses and this impacts the waveguides performance. This could also explain the difference in results.

Task 2 Analysis: This section will cover the results gathered from simulating the halfwave dipole in the software provided.

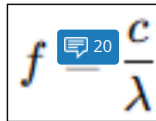
The most notable result recorded was the S-parameter reading which symbolises the difference in the expected S-parameter reading and what was found through the simulation with the result of 1.24 GHz and the expected as calculated below of 1.36 GHz. However, this can be explained due to the parameters laid out by the assignment brief as it was specified that the halfwave dipole should operate off of 50 ohms. In fact, a halfwave dipole should always operate off of 75 ohms to achieve maximum effectiveness.

Where:

f = Resonant Frequency

λ = Wavelength

c = Speed of Light


$$f = \frac{c}{\lambda}$$

When this equation is used with the input of 220mm as the wavelength the resultant resonant frequency is shown as 1.36 GHz. This is what should appear as the lowest value on the S-parameter reading, this shows that the simulation software could have been malfunctioning or, possibly, the dimensions could have been inputted incorrectly, but as stated above the dipole should be operating on 75 ohms.

However, the other piece of data gathered from testing was the 3D polar gain chart, and this data is the exact same as what was predicted before testing as all half wave dipoles with no additional attachments have very similar gain charts.

Conclusion:

In conclusion this testing was a success as the vast majority of testing results were found to be the same as predicted which is a strong indicator of the testing being gathered and tested correctly. The first task which was testing two different materials as mediums on wave guides was conclusive and laid out the advantages and disadvantages of both, but in this case the vacuum proved to be better in this frequency range, as the frequencies were very high and the steady state of a vacuum ensures the stable and reliable results of future testing in this frequency range. But the disparity of what was predicted and what was gathered for the S-parameter of the halfwave dipole simulation should be rectified so that the design for the antenna can reach maximum effectiveness by changing the resistance value in future.

References:



- [1]. R. E. Collin, Foundations for Microwave Engineering, 2nd ed. Wiley-IEEE Press, 2001.
- [2]. C. A. Balanis, Advanced Engineering Electromagnetics, Wiley, 1989.
- [3]. M. P. Moghaddam, "Design of Rectangular Waveguides for Microwave Transmission," IEEE Transactions on Microwave Theory and Techniques, vol. 45, no. 11, pp. 2263-2272, Nov. 1997.
- [4]. J. D. Kraus, Antennas, 3rd ed. McGraw-Hill, 2002.
- [5]. C. A. Balanis, Antenna Theory: Analysis and Design, 4th ed. Wiley, 2016.
- [6]. T. S. Rappaport, Wireless Communications: Principles and Practice, 2nd ed. Prentice Hall, 2002.

UAVs and RADAR and Their Future

Introduction:

Radar systems have been an integral part of air traffic control and aviation safety for many years, only interested in detecting or tracking large aircraft. The advent of unmanned aerial vehicles (UAVs) or drones added complexity. Stealth, low-profile, low-flying vehicles are being utilized for all manner of purposes, from recreational flight to military and commercial applications. The present radar technology that is built to be utilized against huge visible targets might not be usable in the event of detection of drones in the majority of instances where the drones have stealth technology incorporated in them minimizing the radar cross-section (RCS) to the fullest. Below is the report on problems to identify the drones by utilizing radar technology, how the problem was then addressed using the advancements which were subsequent, and considering the social and environmental factors of such systems in real life. Lastly, recommendations on how radar effectiveness can be improved to identify drones.

Literature Review:

Drone Detection Challenges

Traditional radar systems are tuned to search for big metal targets such as planes or missiles. However, most drones, especially consumer-grade UAVs, have metal content and sizes that are huge obstacles for traditional radar systems. Drone aircraft, especially small ones, have a very low RCS, i.e., reflect very weak radar energy towards the radar receiver. Very weak reflection strength is extremely difficult to track such devices. Secondly, all drones consist of radar wave reflectivity materials like plastics and composites that render them even invisible. [1]

Thirdly, even drone flight paths are the basis of other problems. Drones, as opposed to manned airplanes, can hover stationary, fly low, and travel distances at much lower speeds than during cruising. They can bank in ways unusual or make sudden turns, through autopilot and GPS. These conditions render it extremely difficult to be detected by traditional radar, which is best at detecting high-speed aircraft at high altitudes. Radar clutter in or close to urban areas or over water may also prove to be a hindrance to the radar in detecting drones. [2]

The second important challenge is the creation of 'swarming' drones, whereby multiple drones are in close-air proximity. Not just a technical issue but also a security issue because swarming drones are difficult to detect by providing a cumulative RCS that can't easily be distinguished from other targets. Detection systems will thus need the ability to differentiate between a multitude of objects and objects in close proximity and identify them as drones rather than a large target. [3]

Recent Technological Advances –

Recent times have seen a succession of technological advancements in radar technology to combat such challenges. The key developments brought forth to drive abilities to detect drones are as follows.

1. Phased Array Radar Systems

'Phased array radar' is a form of radar technology that sends and receives signal through an array of some finite number of antennas. This system scans the radar beam electronically without movement, which allows it to sweep rapidly over a wide area. Phased array radar systems are effective against small UAVs as they are able to sweep a wide area and can identify small targets. High-resolution phased array systems can be constructed that will allow us to differentiate drones from other objects in the air [4]. They also enable quicker updates of objects in tracking, which is vital in keeping abreast of the high speed and volatility of drone flight.

2. Low-Frequency Radar Systems

Low-frequency radar systems have also been an efficient solution to drone detection, more so low altitude flying drones. Low frequency radar systems are less bothered by rain or fog that weaken high frequency radar systems. The lower frequency radars also have longer ranges with the characteristics of the electromagnetic spectrum and are less prone to jamming. These systems are suitable for detection of drones in clutter, i.e., urban areas, where the traditional radar systems are unable to differentiate between the drones and the cluttered environment [5].

3. Multi-static Radar Networks

Multi-static radar is the utilization of an array of radar receivers and transmitters at more than one site, i.e., on the ground and/or on several platforms (e.g., satellites, aircraft). The 'networked' approach has improved target triangulation and target track of low-speed or high-speed targets such as drones. By fusing data from multiple points, these kinds of systems give a better picture of the airspace and make it harder for drones to take advantage of radar blind spots [6]. It is particularly useful for detecting drones at low altitudes where conventional radar systems are less effective.

4. Machine Learning and Artificial Intelligence (AI) Integration

Integration of machine learning and AI (Artificial Intelligence) with radar systems has been extensive. Machine learning algorithms can be used to train radar systems to recognize the signature patterns of drones. Radar systems can detect drones, birds, and other airborne objects which may look the same on radar, such as small aircraft or even large insects. Machine learning algorithms can process huge raw data and recognize patterns that the operator could not recognize. In addition, AI systems can be trained to improve the detection rates by learning from new data, thus improving performance in a dynamic drone technology environment [7].

5. Cognitive Radar

'Cognitive' radar systems are making the future of radar technology. They are outside the range of traditional radars to detect targets, they possess the capacity to adapt to stay in harmony with dynamic environments by changing their operating systems in real time based on evolving situations. Cognitive radar systems utilize AI to adapt radar waveform and signal processing parameters in a manner that they can improve detection and tracking of UAVs in operational environments. These systems are able to greatly improve detection of drones by optimizing the performance of the radars depending on specific mission needs or environment.

Societal and Environmental Impacts:

Adoption of advanced radar systems as a method of drone detection has tremendous society contributions but with some concerns. Sensitization on such effects is required so as to balance between security needs and expectations of the public. Examples are given below.

1. Social Benefits

The greatest social benefit of advanced drone detection radar systems is heightened security. The systems will deter intruding drones from penetrating the restricted airspace, and that is very convenient to have around airports, military bases, and sensitive facilities such as power plants or government offices. By detecting drones, radars can discourage illegal activities of drones as spycraft or vectors of harmful agents, and radars are a leading edge in counter-measuring the threat since drones are a means of attack or terrorism [8].

Second, enhanced drone detection would enable the safe incorporation of drones into national airspaces. As drones are increasingly utilized for commercial purposes like deliveries, surveying, and monitoring, there is a requirement to make sure that drones and manned aircraft can coexist in the skies without incident and that airspace is used in a way that is orderly.

2. Privacy Concerns

On the negative side, the application of radar systems, even more so AI-based, can be threatening where there is privacy. The systems can monitor people and public activity on autopilot phases. The high-tech capacity of radar systems can be a possibility to track civilians without knowledge, putting into question rights and privacy of information. For example, AI systems can be utilized to monitor groups or individuals based on their radar signatures without even their engagement with drones. Issues of this nature will have to be addressed by improved policy and regulation [9].

3. Environmental Impacts

Radar technology, particularly higher frequency radar technology, can impact wildlife. Experiments revealed that certain radars affect certain animals, birds and bats being a good example, in such a way that they alter their behavior based on the way they are affected by electromagnetic fields. The second long-term environmental effect of widespread radar deployment is also being studied. Some animals, highly susceptible to radar effect, such as migratory birds, would have an effect on their migratory pattern. Scientists need to exercise additional caution towards such impacts when using radar systems in ecologically sensitive regions, and experiments need to be designed in a way that it is known how the effect can be kept to a minimum [10].

Discussion:

Radar Technology for Drone Detection –

Radar technology has significantly improved detectability of drones, but much potential is still present for enhancement.

One of the strongest limitations is that most radar systems won't see drones at greater ranges. While phased array and lower frequency radar will detect smaller UAVs, they will typically not provide the same degree of detail one would desire when tracking a specific one in particular. The others with higher frequencies, such as air traffic control radar, are very accurate but easily interfered with and less sensitive to small drones. Implementing AI into the radar system is an interesting field of investigation in the sense of avoiding such accidents; using machine learning, radar systems can be trained to know how to distinguish drones from other objects such that incidents of false alarms significantly reduce.

Yet, as has already been ascertained within this report, these systems require a significant amount of training and enormous amounts of data in order to function at their best. In addition, AI models will require frequent updating in order to take into consideration the addition of new types of drones and new flight routes. Multi-static radar networks can potentially see more of the air space and thus detect drones more successfully. The problem is to gather data from multiple radar stations and to get the systems to work together in real-time. Particularly this is highly difficult in dense environments such as urban regions or dense electronics interference zones where radar systems are becoming problems to delineate drones from other targets. [11].

Proposed Solutions and Improvements –

1. Hybrid Radar Systems

If all the different radar technologies such as phased array, low-frequency radar, and cognitive radar are integrated into a hybrid system, then it will be an optimized detection capability.

Each technology suits a particular environment, and together, a robust system with the ability of drone detection in diverse environments will be created. For instance, long-range detection can be achieved through the usage of low-frequency radar, and high-resolution tracking of a specific UAV can be achieved through the usage of phased array radar. Cognitive radar can be applied in real-time adjustment of system parameters to optimize the performance in relation to operating conditions.

Additional investment in the creation of more sophisticated machine learning algorithms would allow radar systems to detect drones and distinguish them from other objects. Deep learning, in particular, would be used to demodulate complex radar signals and detect patterns that would be difficult for regular algorithms to detect. Moreover, AI-based systems ought to be able to learn and develop over time to adapt to new drone models and evolving tactics, with higher detection rates. [12].

3. Ethical and Privacy Laws

To prevent invasion of privacy, there must be effective privacy and ethics legislation when utilizing radars. This may involve restricting applications of radar data to non-drones-related intelligence. There must be effective legislation to prevent utilization of radars for mass surveillance of people or groups without reason and control. Public disclosure of radar capabilities as well as what they cannot provide can help in preventing fear of invasion of privacy.

4. Mechanisms for Environmental Protection

The researchers and regulators would need to collaborate to recognize threats to the environment by the radar systems and take care to avoid them. They can do this by limiting flight of high-frequency radar systems over sensitive ecosystems or by instituting regulations that limit exposure of wildlife to radar. Installation of low-power radar systems would minimize environment risk but still accomplish adequate detection of drones.

5. Cooperative Radar Networks

The creation of cooperative radar webs that collect information from a series of radar sources (ground-based, airborne, and space-based radar systems) can heighten the possibility for detection. The webs would create redundancy and denser monitoring of airspaces and thus improved detectability regardless of whether an attempt is made to conceal it by hovering or flight away from areas of radar blind spots.

Conclusion:

The phased array radar, low-frequency radar, artificial intelligence-based solutions, and multi-static radar solutions are all technologies that have somehow assisted in detecting drones. Issues still persist in detecting the drones at long ranges, discriminating drones from other objects, and addressing the needs of privacy and the environment. Hybrid radar technology, sound AI algorithms, and sound ethical guidelines must be employed to maximize the possibility of detecting drones without causing negative effects of integrating the radar. Radar systems must respond with adapting mechanisms because drones employ technology to outrun with drones in order to make integrating drones into national airspace possible safely and counter drone threats.

References:

- [1] H. Liu, W. Zhao, and X. Zhang, "Challenges and advances in low-frequency radar for UAV detection," *Journal of Radar Systems*, vol. 15, no. 2, pp. 185-197, 2020.
- [2] M. Sabatini and S. Tescari, "Radar cross section and detection challenges for small UAVs," *Aerospace Science and Technology*, vol. 20, no. 5, pp. 340-351, 2021.
- [3] D. Cavicchi, L. Panziera, and E. Canessa, "Radar detection of small UAVs: Challenges and solutions," *Journal of Aerospace Technology*, vol. 12, no. 3, pp. 45-61, 2020.
- [4] J. Friedman and B. Ziemer, "Phased array radar for small UAV detection," *IEEE Transactions on Aerospace and Electronic Systems*, vol. 56, no. 4, pp. 3101-3111, 2020.
- [5] Z. Zhang, J. Wu, and S. Ma, "Low-frequency radar systems for UAV detection in complex environments," *Radar and Communication Technology*, vol. 13, no. 4, pp. 243-257, 2022.
- [6] A. Cazzaniga, A. Fessia, and A. Bruschini, "Multistatic radar networks for improved UAV detection," *International Journal of Radar and Sonar Systems*, vol. 38, no. 7, pp. 789-804, 2021.
- [7] M. Ghafoor, S. Aziz, and M. Majid, "AI and machine learning for improved radar detection of drones," *Journal of Machine Learning and Engineering*, vol. 8, no. 1, pp. 22-35, 2023.
- [8] F. Yin, C. Yu, and L. Zhang, "Counter-measures against UAVs: Role of new generation radar systems," *Military Technology Review*, vol. 8, no. 1, pp. 54-67, 2022.
- [9] R. Harrison, P. Smith, and M. Jones, "Privacy implications of radar systems in public spaces," *International Journal of Privacy and Surveillance*, vol. 15, no. 2, pp. 102-118, 2023.
- [10] G. McNeill and D. Woods, "Challenges in detection and countermeasures of UAVs in urban environments," *Proceedings of the 2021 International Symposium on Aerospace and Electronics Systems*, pp. 98-112, 2021.
- [11] A. H. Sheppard and B. N. Cohen, "Multistatic radar for small drone detection in complex urban environments," *Journal of Aircraft and Radar Systems*, vol. 35, no. 6, pp. 651-664, 2022.
- [12] J. G. Weber and L. Chang, "The role of cognitive radar in drone detection systems," *Radar Science Journal*, vol. 25, no. 8, pp. 459-472, 2023.

59

/100

PAGE 1



Comment 1

Good Work,
the first page or the tile page of the report should have the name, student ID,
Module Name, Module code, Title of the Coursework, programme of study. Most of
these are in the title page, but however few are missing.

PAGE 2

PAGE 3

PAGE 4



Comment 2

It is better to number each heading



Comment 3

The
citation should be mentioned before the full stop



Comment 4

The
citation should be mentioned before the full stop



Comment 5

The
citation should be mentioned before the full stop

PAGE 5



Comment 6

It is
better to add figure title for each figure Eg: Figure 1: [Brief Description of
the figure] is appropriate and effectively communicates the content and purpose
of the figure. It provides readers with a clear reference point, making it
easier for them to navigate through the document and understand the
significance of the visual representation.

PAGE 6



Comment 7

This is folded dipole antenna



Comment 8

It is
better to add figure title for each figure Eg: Figure 1: [Brief Description of
the figure] is appropriate and effectively communicates the content and purpose
of the figure. It provides readers with a clear reference point, making it
easier for them to navigate through the document and understand the
significance of the visual representation.

PAGE 7

PAGE 8

PAGE 9



Comment 9

It is better to use similar type of alignment throughout the document



Comment 10

It is
better to add figure title for each figure Eg: Figure 1: [Brief Description of
the figure] is appropriate and effectively communicates the content and purpose
of the figure. It provides readers with a clear reference point, making it
easier for them to navigate through the document and understand the
significance of the visual representation.

**Comment 11**

It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure. It provides readers with a clear reference point, making it easier for them to navigate through the document and understand the significance of the visual representation.

**Comment 12**

It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure. It provides readers with a clear reference point, making it easier for them to navigate through the document and understand the significance of the visual representation.

**Comment 13**

It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure. It provides readers with a clear reference point, making it easier for them to navigate through the document and understand the significance of the visual representation.

**Comment 14**

It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure. It provides readers with a clear reference point, making it easier for them to navigate through the document and understand the significance of the visual representation.

**Comment 15**

It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure. It provides readers with a clear reference point, making it easier for them to navigate through the document and understand the significance of the visual representation.

PAGE 15



Comment 16

It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure. It provides readers with a clear reference point, making it easier for them to navigate through the document and understand the significance of the visual representation.

PAGE 16



Comment 17

It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure. It provides readers with a clear reference point, making it easier for them to navigate through the document and understand the significance of the visual representation.

PAGE 17



Comment 18

It is better to use the equation editor within MS word. It will allow you to produce equations that look better than this.

PAGE 18

PAGE 19



Comment 19

Good analysis



Comment 20

It is better to use the equation editor within MS word. It will allow you to produce equations that look better than this.

PAGE 20

PAGE 21



Comment 21

It is better to have reference at the end of the document.

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

PAGE 31

PAGE 32

GRADING FORM: EMR MAY

GABRIEL PAN

59

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.



Demonstrates engagement with a wide range of literature including independently sourced materials. Credible set of sources is used. References include textbooks, journal articles, and online resources. In-text referencing is consistently applied and relevant to the context. Referencing is consistent and correctly formatted using IEEE style. The number of peer-reviewed academic journal articles remains limited.

6.8

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 extensive and demonstrates competent critical understanding of well-established concepts and principles in antenna and waveguide theory. Good general understanding of waveguide theory. Demonstrates understanding of how material choice affects wave propagation. Description on radar is good. However, Modes 2 and 3 were not identified, and theoretical calculations were not completed for either the vacuum or Teflon cases. Also, some theoretical assumptions regarding impedance matching lack depth.

15

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.



Some critical evaluation of electromagnetic radiation concepts, with a tendency toward description. Formulas are applied consistently. Theoretical and simulated results are compared for antenna design. Parts of the conclusion are overly descriptive. Since the modes were not identified, the frequency variation between the theoretical and simulated results for the waveguide was not calculated. Additionally, including a table comparing theoretical and simulated resonance frequencies, along with percentage error, would enhance clarity and credibility.

13.20

Designed effective waveguide and antenna systems with commercial awareness.

Radar analysis addressed privacy, safety, and environmental concerns.

Applied advanced tech like phased arrays and AI for innovation.

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.



An advanced application of a range of established methods, materials, tools, and techniques.

14

Excellent use of HFSS simulations, including all required plots: field magnitudes, vector plots, S-parameters, and radiation patterns. Screenshots are clear and well-labelled. The application context is well considered and insightful. To improve further, specify the boundary conditions used (e.g., PEC, radiation boundary) and the solver settings

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.



The report demonstrates a basic level of structure and coherence. Report is clear, but improvements are needed for a higher overall quality. It would be better to use a structured summary in the conclusion and explicitly connect the findings to the design goals. Proper alignment, clear figure captions, the use of tables, and thorough proofreading would have improved the overall quality of the report. Additionally, it is important to adhere to the word count.

10