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Development of an Antenna Array Radiation Model in Propagation Systems for a Low Power Smart Antenna System

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ABSTRACT

Antennas have become an intrinsic part of our lives as there is a progression of technology and not many people understand how information is transferred through these devices. There are various ways of determining how antennas can transmit energy efficiently, and not everything is seen on the antennas themselves, as there are some problems that may arise from the transmission cables that they are connected to as well. Some ways of determining how an antenna can send energy signals are through an antenna's radiation pattern. An antenna radiation pattern is a way to determine how a specific antenna radiates energy or propagates information. This study deals with understanding radiation pattern graphs, array patterns, beam scanning, and many other graphs. The understanding of all these is to efficiently be able to use antennas and reach the maximum possible distance that it can achieve at the right positioning of the antenna, and where it can have a signal boost from another device. This system can be used for low power smart antenna systems.

Key words: Radiation Pattern, Azimuth, Directivity, Antenna Systems, Low Power Smart Antenna Systems.

1. INTRODUCTION

The antenna was one of the breakthroughs that we're able to shape and mold the way we transmit and receive information daily, but how does an engineer know if the antenna is working the way it should, or how effective it can radiate energy and how far it can transmit it from? That is where the radiation pattern and other graphs come in [1,2].

The computations on how an antenna is designed were based on anisotropic source or a source where it can radiate energy equally in all directions. However, in practical applications, this is far from true as various factors can affect the performance and transmission of an antenna. The transmission of antenna signals would also depend on where the antenna is located and what surrounds it. With, the isotropic source is being used as a basis because it is the closest way of having a rough estimate on what is expected on the antenna being designed [3,4].

Understanding how antennas operate is important for engineers as it is the heart of our generation where the gathering of information is constantly being acquired through the use of electronic devices, of which they can receive it through antennas one way or another. The way we use the internet would also require antennas and satellites to work as this is the basis of how transmission of information occurs worldwide. Without the development and understanding of how these antennas operate, we would probably not come as far we have today [5,6].

Although these concepts and theories are already developed, there is still room for improvements to be made for efficiencies of systems to have lesser power losses that may occur, and maybe more advancements can be discovered shortly to maximize the potential of how we can communicate with each other around the world at cheap costs [7,8].

2. BACKGROUND OF THE STUDY

Antennas have made a huge impact on how our society works today, therefore it is important to understand how these antennas work to be able to understand why there are areas with very strong signal reception from a certain carrier, or why there is no reception in a specific area. For example, for antennas that are mounted on ships, receiver antenna mounted on the ship may receive data from more than one path which may include either a constructive or destructive interference and a phase shift in the signal received [9].

Antennas come in different styles and sizes depending on what its purpose is. There are simple dipole antennas, Yagi Uda antenna, a folded dipole antenna, and many others. An antenna array is an antenna that is composed of many different antennas acting as a single antenna for transmitting and receiving radio waves. Antenna arrays are important it can have a high gain and directivity along with beam scanning, an advantage of using an antenna array is to control the radiation

pattern of the sidelobe level. Another application of an antenna array is alongside the production of 8K HD video with high-resolution images, this would require frequencies in the terahertz range to be able to enjoy having these features [10,11].

As previously stated, antennas have paved the way for many advancements in technology, some of which involve the way we communicate and transfer data. We can see that antennas not only focus on how we communicate but how we can enjoy entertainment as well. From having big antennas and satellite dishes on our roofs, we are now able to receive signals with just a mini antenna in our living room or just connect our televisions to the internet and enjoy streaming services [12]. This would not have been made possible without the help of antennas to transmit and receive signals from other antennas or satellites [13].

3. STATEMENT OF THE PROBLEM

Understanding how antennas work is only taught in the classroom, and sometimes with minimal visualization of experiments regarding this, a student studying the field of communications may have a hard time understanding the theories without the applications of the topic regarding antennas. This study is to aid future researchers in understanding what are the antenna properties and how to understand it.

Some of the properties that will be shown in this paper are not necessarily taught inside the classroom, but it can be understood with prior background on different electronics and communications subjects. This is to enhance learning on how antenna radiation patterns look like, what beam scanning, the array pattern, the impedance of the system concerning frequency, and many more.

The study will deal more with understanding the representations of the graphs and will not focus on the mathematical side of the whole system as this can be learned alongside the theories that are taught. With the graphical representation of radiation patterns and others, a student can enjoy the topics being discussed inside the classroom and appreciate how communications are being implemented in the real world with data that will help understand how these antennas work.

4. SIGNIFICANCE OF THE STUDY

The significance of this study is to further understand what the graphs of antenna properties are to deeper understand how antennas work. The radiation pattern of an antenna is one of the most important properties to understand because it is how the antenna much energy is directed at a certain direction and how narrow or wide is the propagation in that direction. This is important because the radiation pattern is the one property that can help an engineer determine the most efficient direction that the antenna will work. The array pattern determines how directive in a certain direction the antenna array is to a certain degree (azimuth) and in what factor of the wavelengths, the spacing between the arrays should be for better performance.

Antenna's theories would be supported by this study as concepts of antenna theories would still be applied to the antenna array. It has a somewhat similar concept to the Yagi Uda, wherein the more elements the antenna array has, the more power the system has. This is because the radiated power in each element of the antenna array is being added together to further enhance the power in a certain direction while canceling power in undesired directions.

5. DESCRIPTION OF THE SYSTEM FOR LOW POWER SMART ANTENNA APPLICATIONS

The system created is a study on an antenna array, by determining the length of each element, and their spacing from each other. From there, various properties with importance to how to study antennas are produced using MATLAB [14].

MATLAB was used to produce these functions as it is easier to produce with creating a code since MATLAB already has certain set functions and commands to produce results on a certain antenna type. Variables were changed to determine how the system would react.

6. METHODOLOGY

MATLAB was used to implement the experiment of determining properties of an antenna array from what an antenna element’s length should be, and what the spacing in between the elements should be as well. MATLAB was chosen as it can perform calculations with very minimal loading time.

MATLAB was also chosen as it already has specific libraries and commands that aided in the experiment, it was easy to understand and use and to change parameters to best fit to what the researcher decided to understand.

7. REVIEW OF RELATED LITERATURE

A study was conducted on how a conceptual 34x34 array would be implemented for 8K resolution for video transfer and streaming which would deal with very high frequencies that would reach terahertz or would mostly operate in the terahertz region. They designed a 34x34 array that would deal with frequencies that range from 125-300GHz, they did this by proposing a technique that deals with the isolation of antennas with metallic via-holes and then in the periphery of the patch antennas embed a circular dielectric slot; they proposed this as it is claimed to have better gain and efficiency. They optimized the design by using the method of moments and the finite element method to base the full-wave electromagnetic solvers.

Another study conducted was determining a way to evaluate antennas accurately on ships as there may be areas that a ship may not be able to receive signals from certain angles of the radiation pattern of the antenna installed on the ship due to the scattering caused by factors on a ship. Measurements done on ships will also have problems that should be taken into account due to the multipath effect that can occur, however, the suggested ways of solving the multipath effect is tedious and time-consuming. The researchers proposed a two-ray model to be able to describe the scenario at hand, then validate the created model using data acquired through different frequencies that the model is tested upon, and study the data to see if it could provide knowledge to the researchers as to the effect of reflection of signals from the waves concerning what is measured on the data of the antenna.
A unique study proposed a way of studying the characteristics of antenna radiation by using small unmanned aerial vehicles (UAV). They proposed this because antennas that are large and fixed are difficult to implement a test field and practically impossible due to other factors. They proposed the use of UAV since it is a rising technology and they believed that it has come to the point of maturity wherein they can apply the UAV to their study of understanding radiation patterns using a drone with a connected RF transmitter and test antenna, the important factors to this study is acquiring the position of the UAV and achieve asynchronous signal. They tackled this by using a synchronized GPS receiver that is placed on the ground that would be able to track where the UAV is in real-time. This is to be able to make accurate data on the studies as to whether the proposed UAV system that they are proposing is an accurate representation of the data that they need which is needed to determine antenna radiation properties.

Another study also deals with the wireless terahertz technology which would need higher transfer rates to be successful. One of the materials of interest for producing devices that can execute these types of operations on this frequency is graphene. This is because graphene can have its conductivity complex altered or tuned, which can be used in nanoantennas and other different applications. However, graphene antennas have low gain and have radiation inefficiencies. They assumed that the graphene sheet is not exposed to any external magnetic field and that its conductivity is isotropic.

Another study focused on determining the direction of arrival and time delays of a certain system because of the number of paths wherein the data can pass through, as well as the relationship between them. They deemed the study important as in multipath measurements, the accuracy of these directions of arrival and time delays is important specifically for an environment where it is a non-line of sight. They proposed using the azimuth angle of arrival and the elevation angle of arrival in determining these parameters. It was concluded by the researchers that the algorithm they used and the estimation of the parameters that they needed yielded accurate estimations in bad channel conditions such as low signal to noise ratio and harsh multi-path channels. They also reduced the computational complexity of the algorithm so that it can also be used for applications that do not require accurate estimations for bad channel conditions.

8. THEORETICAL CONSIDERATIONS

The theoretical considerations here are that there are no obstructions to the antenna arrays desired path and that it is implemented in ideal conditions. This is to understand the ideal radiation pattern of a given antenna array for a given frequency. The experiment conducted is merely for a deeper understanding of the radiation pattern that is produced, and how it is interpreted by engineers that will have encounters with these types of systems.

9. DATA AND RESULTS

9.1. Program Output

Figures 1 to 7 shows the antenna system simulations from the antenna element to the impedance.

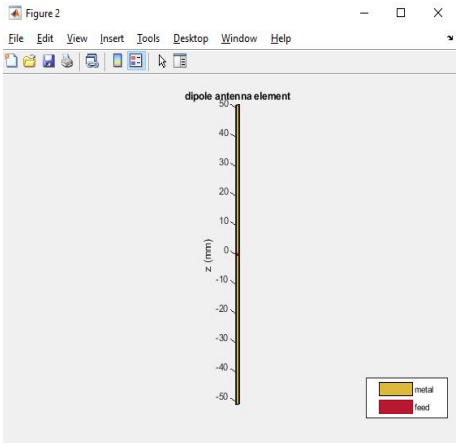

Figure 1: Antenna Element

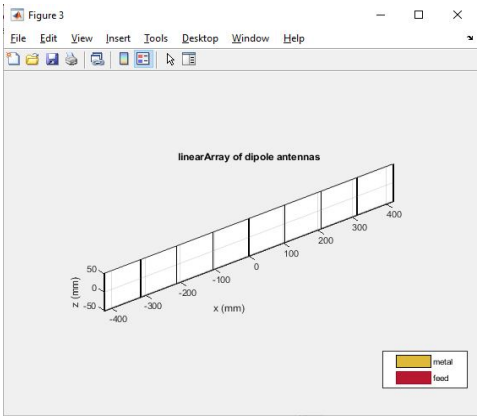

Figure 2: Antenna Array

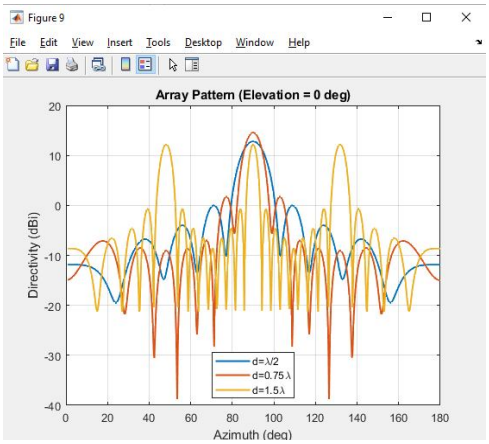

Figure 3: Array Pattern

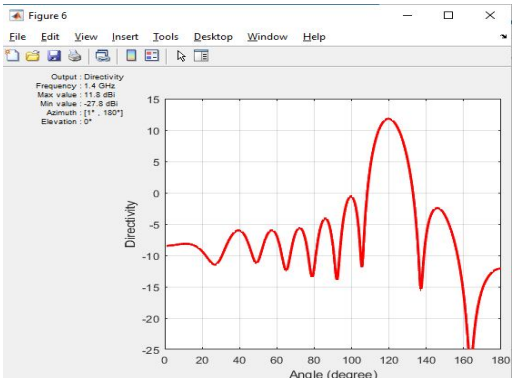

Figure 4: Beam Scanning

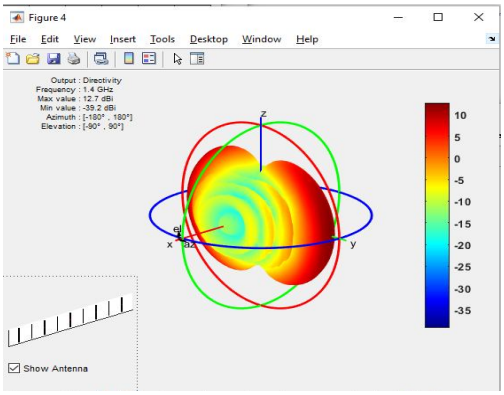

Figure 5: Radiation Pattern

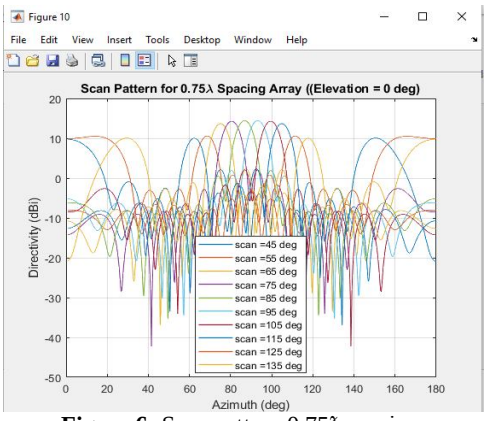

Figure 6: Scan pattern 0.75λ spacing

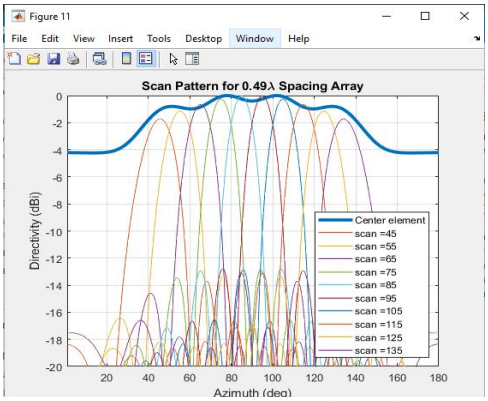

Figure 7: Scan Pattern 0.49λ spacing

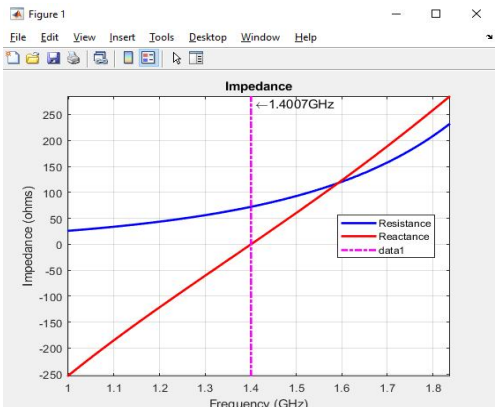

Figure 8: Impedance

10. ANALYSIS OF DATA

From the data acquired, it can be seen how the data is very specific, it can be seen where the antenna's radiation is at its strongest from the radiation pattern that was acquired. It can also be seen as to what the power of the directivity is concerning a certain distance from the antenna array, with a given factor of the wavelength. It can be seen that there are certain distances where there are peak directivities that are produced by the antenna arrays concerning certain azimuth angles, from here it can be determined where the antenna array is most efficient in sending signals.

It can also be seen through the impedance chart that at a frequency of about 1.6GHz resonance will occur this is the point at which the resistance and the reactance of the system would meet.

The scan pattern charts seen below yielded the optimum spacing between antennas to yield higher directivity, it can be seen that the spacing of antennas with a factor of 0.75 of the wavelength produced higher gains with directivity than the ones with a factor of 0.49 of the wavelength, it can be seen that with the spacing of 0.49 of the wavelength, the gain is only unity whereas, with the 0.75 wavelengths, higher gains are achieved.

It was observed that changing the frequency will not change much on the output of the whole system, and most of the data will remain the same. The antenna element and antenna array were also produced through the MATLAB algorithm that was produced. It was observed that these data are useful for a student aspiring to be a communications engineer because all the data that is needed to understand the antenna properties can be seen with the proper code in MATLAB.

11. CONCLUSION

It can be concluded that understanding antenna properties are very important in the learning process of communications. This is because these are somewhat the heart of communications and our society today where information is constantly being hurled at one another, and with the rise of high-frequency technologies such as 5G, these are important as with the development of 5G technology, these antennas, and other communications systems should also be following the trend of the upgrade that we are going to have.

These charts and graphs should not be overlooked, and should not be underestimated, although some of these data and basis may not be used as much as when it was the trend, the concepts and understandings on how to interpret the data that was acquired are very important as other concepts of communications and antenna systems would also come from the fundamentals that were already learned. Innovations on how to implement more efficient antennas are still on their way as the net revolution for artificial intelligence is rising. It is important to understand that the future still lies along with how we can handle and transfer our data with the increase of development applications in the frequencies that are already very high.

The future technology would depend on how these antennas can transfer data to each other, and with the rise of 5G and the 8K resolution technology, these would take a toll on data transfers as consistent and efficient systems are needed, else the technologies that will be discovered and developed will be deemed useless as there will be no equipment able to communicate or cope with it. Therefore, the importance of understanding this topic cannot be emphasized enough, as various other factors will affect how data is being transmitted through these antennas, some of which are a part of the earth's properties and are very hard to go around and avoid.

12. RECOMMENDATIONS

It is recommended by the researcher that future researchers tackle situations wherein interference and other obstacles may also be simulated, to understand the behavior of these types of antennas when there are obstacles in the path. If diffraction will occur in these types of antennas, and if so, how effective is it still able to transmit energy in the direction of diffraction. These are some of the basic paths to which may affect signal transmission by antennas especially when installed on mountain areas.

The additional spacing could also be taken into consideration and analyze as to whether there are more efficient spacing to achieve higher directivity gain of the whole antenna array. Other simulations can also be made to check if there are factors that can affect the radiation pattern of the system if some parameters are changed.

Another suggestion would be to implement the algorithm or the system and check if it can be implemented with folded dipoles instead of a simple dipole system. This is to see how a different antenna array composed of a different antenna would behave, and under what frequencies would it best operate as well as other parameters that can be changed. This can also be conducted to see how different the radiation pattern would become, the impedance graph, scanning pattern, beam scan, and many other graphs. This is to help other researchers also see the expected behavior of a folded dipole if it is possible to be put in an antenna array.

Studies can also create comparisons of antenna arrays and determine which would be the best antenna array to use for certain frequencies or efficiencies perhaps. This study will be to understand why a certain antenna pattern is preferred over other types perhaps. This would deal with the study on outputs as well, graphs compared with each other as parameters are constantly being changed by the researcher depending on the scope of their study.

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