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Design Microstrip Antenna for 6G Application using CST Microwave Studio

Siti Mariam Halid[1], Muhammad Ramlee Kamaruddin[1]*

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

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Abstract: This research focus on designing Microstrip Patch Antenna for a 6G Application. In the sphere of mobile communication, the rate of scientific and technological advancement has never diminished. 6G were introduced to provide customers with high bit rates, low latency, large capacity, as well as a variety of new services and vertical applications. This research aims for an antenna that works on 300GHz where the performance of the antenna was studied and the improvement of the antenna were applied. Hence in this research, an antenna with 300GHz resonant frequency has been designed in CST Microwave Studio. Few designs were done and analyzed. In addition, arrays were introduced where it helps to improve the performances and the arrangement of the array were justified. In this research it will shows Voltage Standing Wave Ratio (VSWR) and also the gain of the antenna, with or without arrays. With addition of arrays, it is proven that the performance of the antenna was increase where it has higher value of gain shown in the results. The overall simulation results showed promising output that can be implemented by others who wanted to develop the actual hardware of the antenna.

Keywords: Microstrip Patch Antenna, 6G, CST Microwave Studio

1. Introduction

In the sphere of mobile communication, the rate of scientific and technological advancement has never diminished. Mobile communication has revolutionized people's lives and has accelerated society's informatization and digitization from standard communication's first generation (1G) through the internet of things' fifth-generation (5G). 5G is projected to especially in this modern era of Internet of Everything (IoE) and serve as a catalyst for the advancement of innovation and progress in all aspects of life. Given that a new development of mobile communication system is released every ten years, around 2030 a commercial mobile network of the 6th Generation (6G) is expected to be ready [1-2].

6G will be involved in a variety of applications, including autonomous driving, robotics, and many more technology applications. This can be achieved with the use of digital twin technology and an

**Corresponding author: mramlee@uthm.edu.my*

automatic control system thus the necessity for human involvement will be reduced. In addition, it is necessary to have very low latency (0.1-1ms) in order to break down the barriers between the real world and the computational realm [3-4].

The value of the parameter used and the type of materials used affect the frequency produced from the antenna. Referring to the research, the comparison between parameters and bandwidth generates different ways of frequency emission. In addition, the size of the patch and feed line from the microstrip patch antenna is the main causes of the change in frequency emission.

This research provides a thorough examination of contentious research subjects in 6G communications, including recent industry developments in antenna design, frequency emission, and spectrum band. It summarizes the study topics' core domains, which is antenna design simulation. These issues were thoroughly examined based on their various sub-domains in order to provide a precise, detailed, and concise conclusion.

2. Materials and Methods

This section will describe the methodology used in this study. The methods were utilized to obtain the research results.

2.1 Graphene

Figure 1 shows the material used for the antenna. A graphene antenna is a high-frequency antenna made of graphene, a one-atom-thick two-dimensional carbon crystal that could improve radio transmission. These improvements would be possible due to graphene's unique structure. Because of the behaviour of electrons, graphene was chosen as the basis for this nano antenna [5]. This is currently being researched and graphene appears to be a feasible basis for antennas.

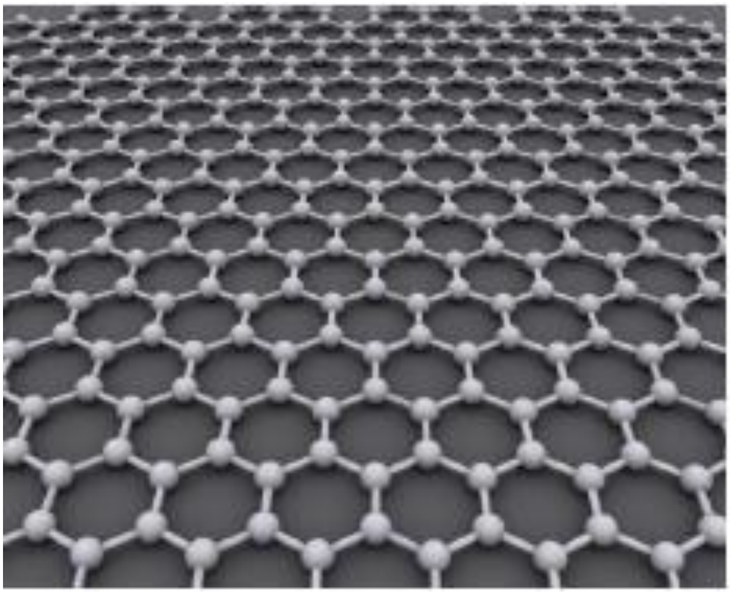


Figure 1: Graphene's Structure

2.2 Methodology

Figure 2 shows the overall flow of this research. Before designing the antenna, the parameter for 300GHz frequency was identified and the data was collected. As the first step was done, a suitable material was chosen before designing the antenna using CST MS. The intensive simulations were done and the performance of the antenna was observed. Here, it focused on the gain of the antenna whether it get great value or did not. An array was added in order to improve the performance of the antenna which may increase the gain, thus the results was observed. The arrangements of the antenna array also played a big role in this research.

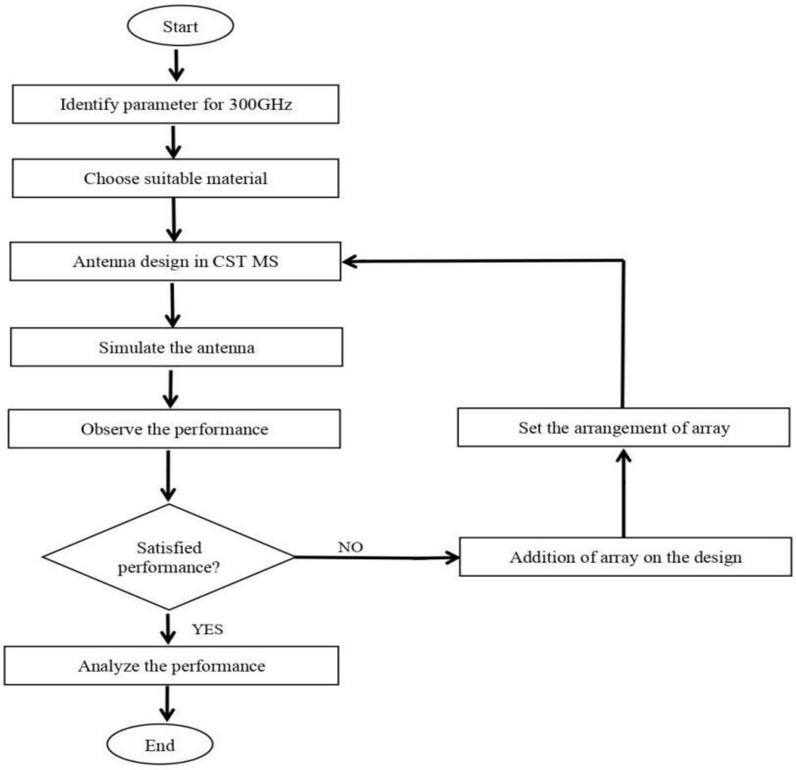


Figure 2: Research flowchart

Before designing a microstrip patch antenna, the resonant frequency and dielectric medium for which the antenna will be used must be determined. The parameters to be calculated as in Eq. 1.

$$W = \frac{C_0}{2fr}\sqrt{\frac{2}{\varepsilon r\ +\ 1}} \qquad \textit{Eq.1}$$

The effective constant of the microstrip antenna was determined from Eq. 2.

$$\varepsilon_{reff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_r\ -\ 1}{\sqrt[2]{1\ +\ \frac{12h}{W}}} \qquad \textit{Eq.2}$$

On the other side, the ΔL was determined by Eq.3.

$$\Delta L_{eff}\ =\ 0.412\ \frac{(\ \varepsilon_{reff}\ +\ 0.3\ )(\frac{W}{h}\ +\ 0.246\ )}{(\ \varepsilon_{reff}\ - 0.258\ )(\frac{W}{h}\ + 0.8\ )} \qquad \textit{Eq.3}$$

While the actual length of the patch was calculated using Eq. 4.

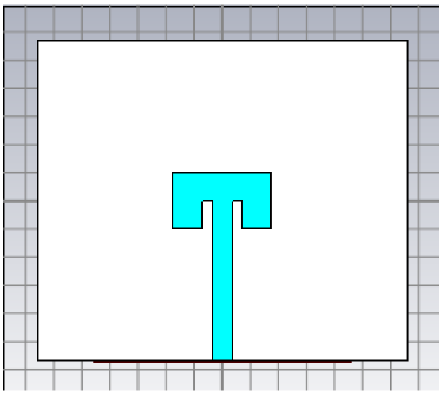
$$L = \frac{1}{2_{fr}\sqrt{\varepsilon_{reff}}\ \sqrt{\mu_{\circ}\varepsilon_{\circ}}} -\ 2\Delta L \qquad \text{Eq.4}$$

3. Results and Discussion

The results of this research were studied and analyzed. Firstly this research will discuss the performances of graphene's antenna, followed by the antenna array with its arrangement performance.

3.1 300GHz Graphene Antenna

Figure 3 shows the actual design of the antenna before it was simulated. Figure 4 is the pattern of the antenna after it has been simulated. The gain and voltage standing wave ratio were then observed.



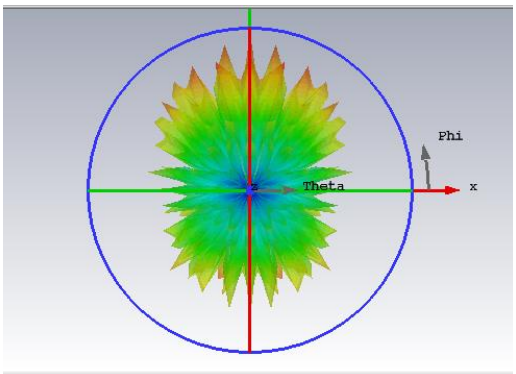


Figure 3: Graphene Antenna Design **Figure 4: Antenna pattern for single antenna**

As this antenna has been simulated, it shows clearly the gain and the value of VSWR. As illustrated in Figure 5 and Figure 6, the gain of the single antenna was 5.498dBi and the value of VSWR was 1.01 and this is a great value because the ideal value of VSWR is 1.5:1.

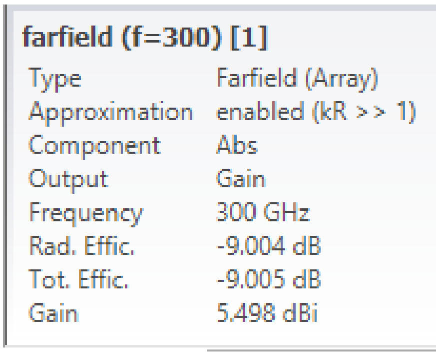


Figure 5: Gain of the single antenna

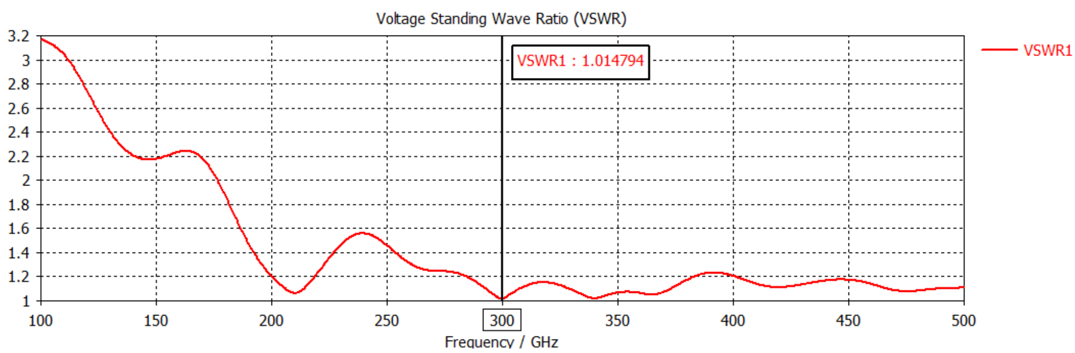


Figure 6: Voltage Standing Wave Ratio of single antenna

3.2 300GHz Graphene microstrip patch antenna array

Figure 7 shows the design of the antenna array. It consists of two arrays with a location of side-to-side with one feeding line. The antenna array was simulated in order to identify whether the gain increases or vice versa.

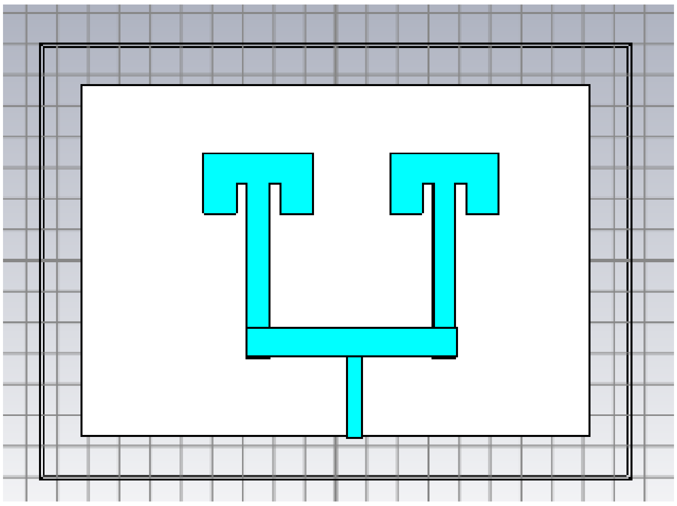


Figure 7: Antenna array side-by-side arrangement

The array's antenna pattern is shown in Figure 8. With a gain of 8.642dBi, the direction of the gain is further towards the y-axis. The installation of the array aids in increasing the antenna's gain, which was previously only 5.498dBi.

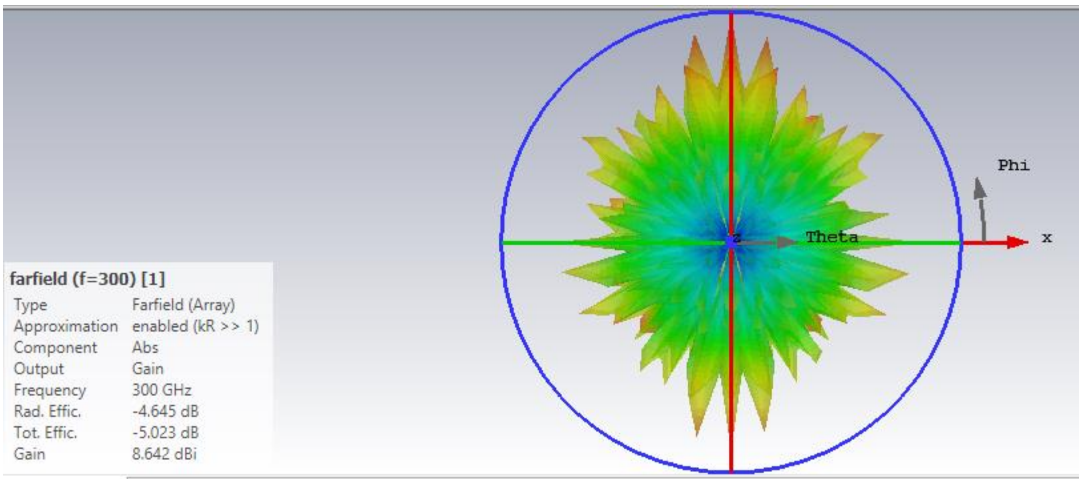


Figure 8: Gain pattern of antenna array side-to-side arrangement

3.3 Graphene microstrip patch antenna array 90° arrangement

As illustrated in Figure 9 and Figure 10 in which the arrangement of the array was set at 90°, the value of the antenna’s gain increased double in number compared to the side-by-side design which currently has the value of 12.92dBi where the maximum gain approach to the y-axis. As conclusion, it can be observed that the arrangement of the array plays a big role in order to increase the performance of the antenna and it can be concluded that the best design for the antenna array was a 90° arrangement.

The antenna specification of antenna design for graphene is shown in Table 1. The working frequency is 300 GHz, and the antenna is a microstrip patch antenna. Graphene, a lossy metal with a resistance of 0.003 to 0.008 ohm per square, is used as the conducting element. The electrical conductivity ranges from 1.25 x 104 S/m to 3.33 x 104 S/m.

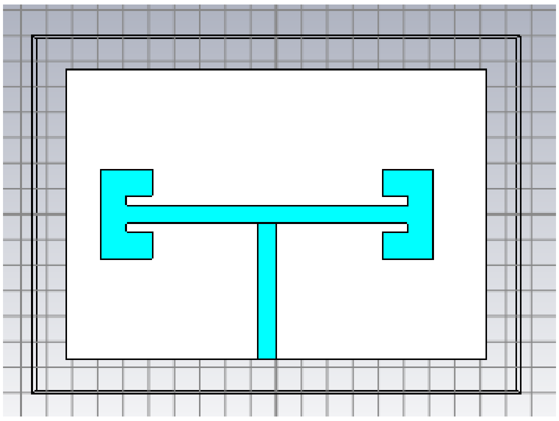


Figure 9: Antenna array 90° arrangement

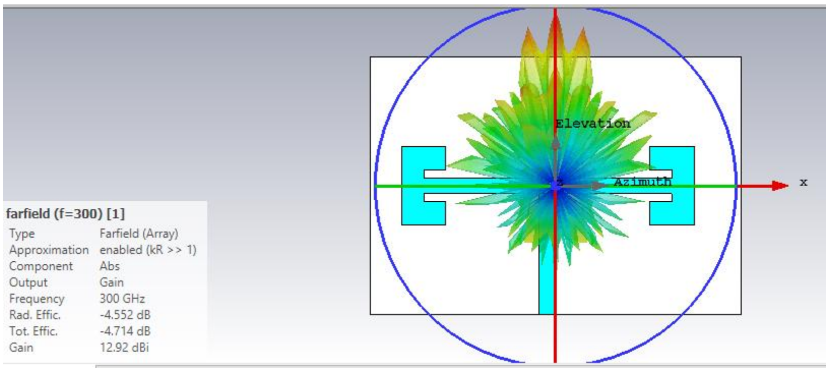


Figure 10: Gain pattern of antenna array 90° arrangement

Table 1: Graphene's Antenna Specification

Item	Parameter Name	Variable Value	Unit or Dimension
1	Operating frequency	300G	Hz
2	Resistivity	0.003-0.008	cm
3	Thickness	> 100	nm
4	Conductivity	1.25 x10^4-3.33x10^4	S/m

Conclusion

The design of the antenna was developed and have reached the desired frequency which is 300GHz. The performances have been upgraded by adding an array to the design in which the position of the array also affected the gain of the antenna. The gain of each design were then been differentiated and analyzed which is the best design with higher gain and the results have been presented in this study. The overall simulation results showed promising output and can be concluded that the best design for the antenna array was a 90° arrangement. Thus it can be implemented by others who wanted to develop the actual hardware of the antenna in order to adapt to the industry.

Acknowledgement

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